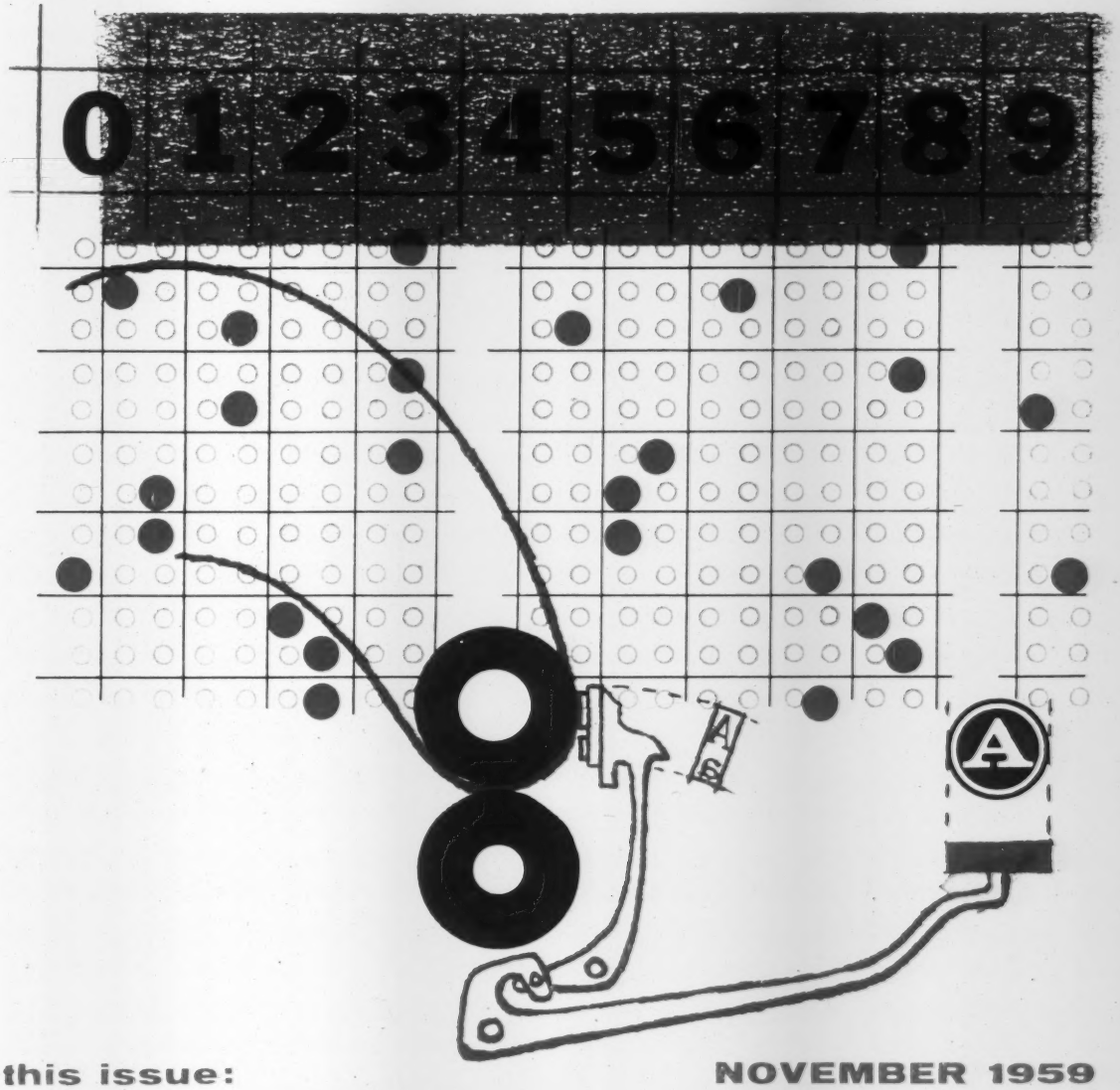
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

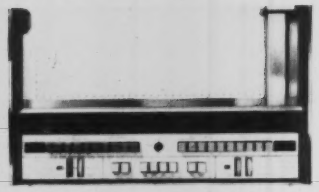


in this issue:

NOVEMBER 1959

Data Loggers 1672
Temperature Transducer Calibrations 1682
Digital Actuators 1686
Millimicron Motion Instrumentation 1688
Electronic Circuitry 1694
Process Control Systems 1714

THIS PRINTING: 34,000



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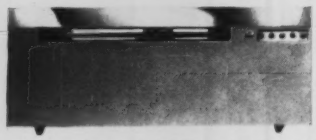

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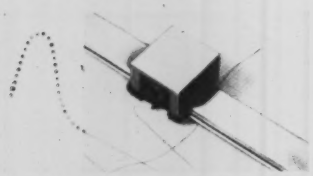

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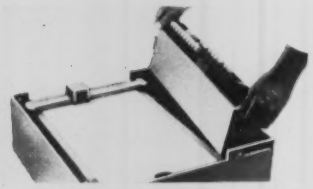

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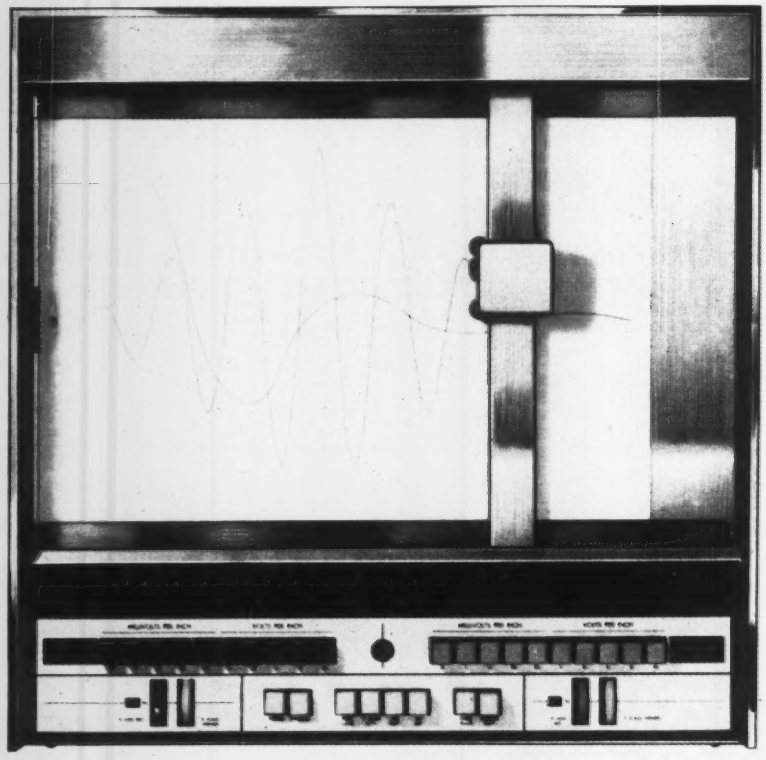

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LI 9-25

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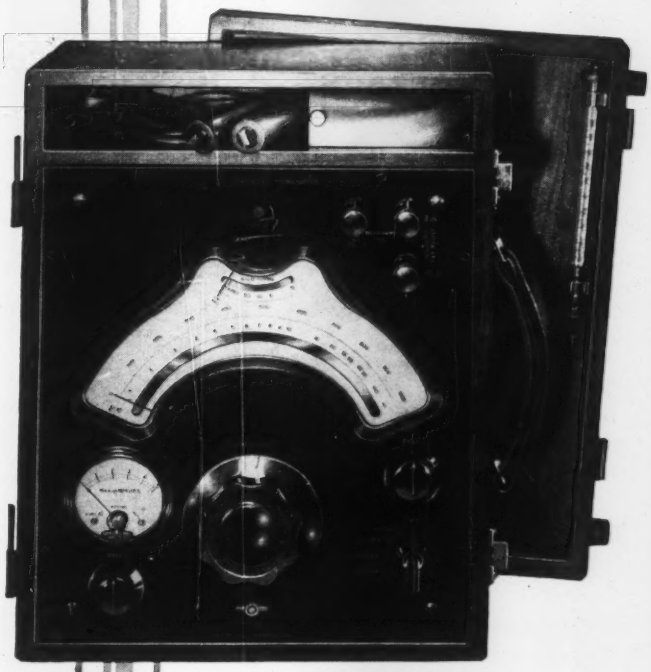

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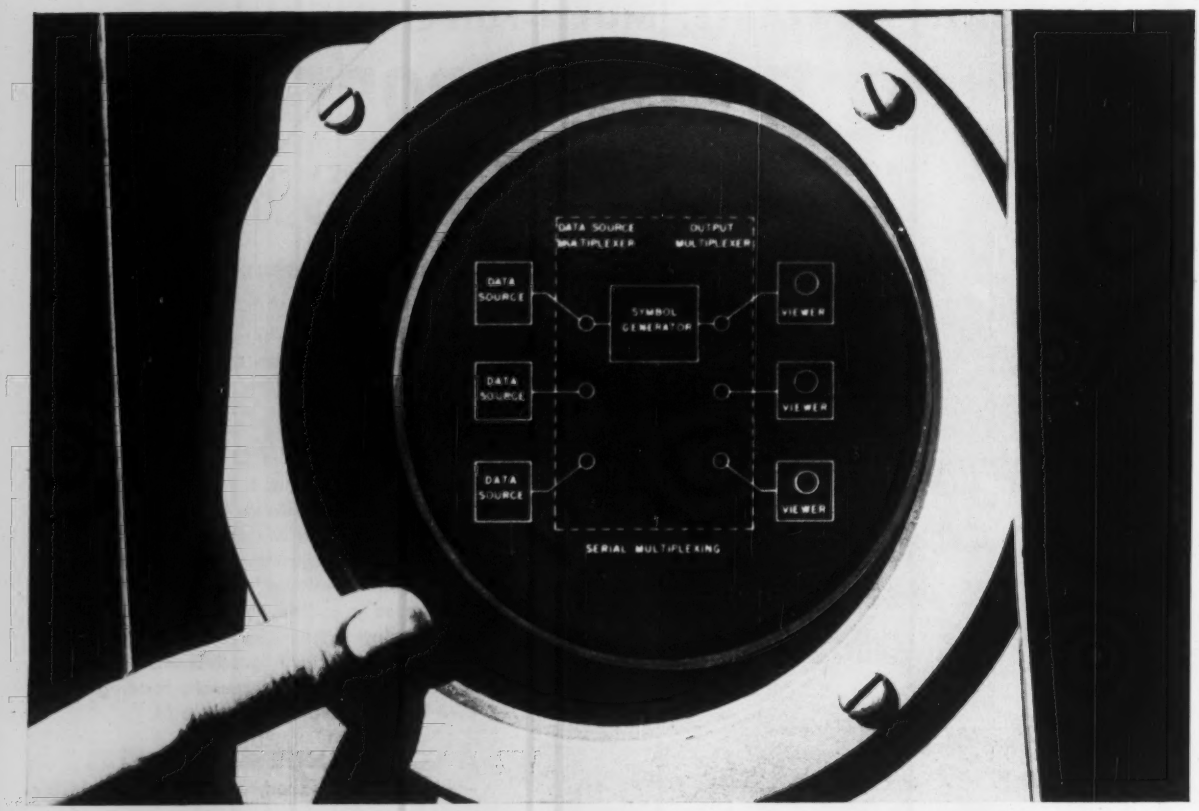

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INSTRUMENTS AND CONTROL SYSTEMS

Formerly INSTRUMENTS and AUTOMATION

NOVEMBER 1959

VOLUME 32 NUMBER 11

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EDITORIAL

Engineering Education Now And Thirty Years Ago, 1666

JAMES C. COE—a professional teacher views today's students with those of thirty years ago

Instrumentation Calibration And Standards, 1667

SURVEY shows lack of standardization facilities

FEATURE ARTICLES

Data Loggers, 1672

MILTON H. ARONSON—survey shows vast variety of types and sizes of available data loggers

How Accurate Are Your Temperature Transducer Calibrations? 1682

ALVIN B. KAUFMAN—technique for accurate temperature transducer calibration includes consideration of thermometer immersion, thermocouple type, bath type, bridge factors, and reference temperatures

Digital Actuators, 1686

T. GIZESKI—available new types include: digital linear positioner; digital control valve; digital force mechanism; digital pump; speed transmission system; motor-type positioner; and variable-torque digital clutch

Millimicron Motion Instrumentation, 1688

JACK McELWAIN—basic transducer types include variable-reluctance, capacity, strain and torsion seismographs

Electrodynamic Standards For Vibration Pickups, 1692

R. R. BOUCHE—a method for standardizing electrodynamic calibrators has been developed by NBS

Electronic Circuitry, 1694

M. H. ARONSON and CHARLES F. KEZER—missile impact telemetering transmitter develops 65 mw at 65 mc; 630 watt d-c to d-c converter has 90% efficiency; short-range radio telemeter for medical use

Digital Building Blocks, 1696

JOHN H. HOSEMAN—design of control systems and special-purpose instrumentation can be simplified by relying on plug-in stages linked together to provide necessary action

Process Control Systems, 1714

FRED D. MARTON—specific gravity of liquid is controlled by bubbler-type differential-pressure measurement; thickness of traveling sheet material is measured by beta-ray source; continuous strip pickling with acid control; automatic turbine switchover via 3-way regulating valve guards power station

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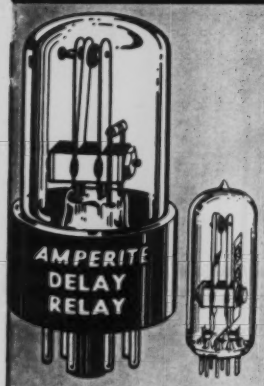

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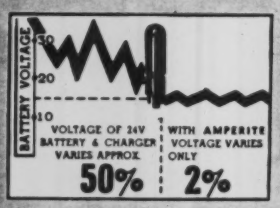

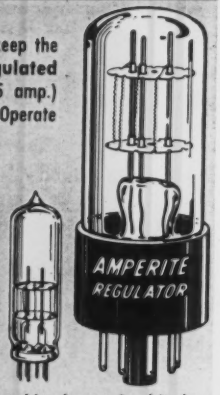

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RELAYS—CIRCLE 4 ON READER-SERVICE CARD
REGULATORS—CIRCLE 5 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 32 No. 11 NOVEMBER, 1959

PRINT ORDER THIS MONTH: 34,000

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Simulation Of Aircraft & Missiles, 1702

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The Journal of THE SOUTHERN CALIFORNIA METER ASSOCIATION

Industrial Flowmetering With Turbine Meters, 1712

BERNARD ARTZ—the turbine-type flowmeter is an accurate, versatile flowmeter capable of operating under high pressure, wide variations in density and viscosity, and at all altitudes

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CIRCLE 6 ON READER-SERVICE CARD

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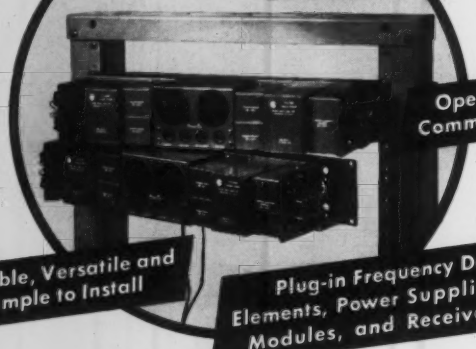
Compatible with all Telemetering End Equipment



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Plug-in Frequency Determining Elements, Power Supplies, Transmitter Modules, and Receiver Modules.

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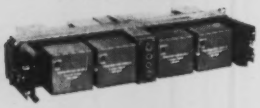
MODEL 1220

The Model 1220 Terminals are normally used in telegraph applications and provide all necessary carrier and loop jack fields, as well as loop current controls. Two transmitters, two receivers, or a transmitter receiver are available on a single 5¼" x 19" chassis.

MODEL 1220A



The Model 1220A Terminals are normally used in telemetering and control applications. The individual modules are mounted on a swing-out chassis and are readily accessible. Four transmitters, four receivers, or two transmitter receivers are available on a single 3½" x 19" chassis.

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SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

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CIRCLE 7 ON READER-SERVICE CARD

to the editor

Editor, I&CS:

I am interested in the topic mentioned in the [Briansky letter on transcendental quasi-polynomials] in Vol. 32, p.970 and would appreciate your forwarding my inquiry to the author.

R. Mohan Prasad
The Foxboro Co.
Foxboro, Mass.

Letter has been sent.

Editor, I&CS:

In the course of a recent meeting, Mr. Henry Gay of Commonwealth Associates, here in Jackson, brought your editorial "Report on Public High-School Course in Modern Engineering Physics," 225 February 1959, Vol. 32, No. 2 to our attention.

We found the article so interesting and stimulating and so much in line with our thinking that we would like to have some reprints if they are available. It has been the feeling of the Director of Vocational Education and myself that we have a definite need for a course of the type described, and we have observed a sufficient interest among the engineering firms in Jackson to indicate that we might meet success if a program of the type described could be organized.

In order to place copies of your article in the hands of persons concerned we would require about ten reprints. Again, congratulations on a fine article that not only had a good suggestion to make but which also described a method of implementation for it.

Norman P. Taylor
Coordinator of
Science Education
Jackson Public Schools
Jackson, Michigan

Editor, I&CS:

Ref. READER INQUIRY A-354

Having just seen your issue of December, noticed the above mentioned reader inquiry from a Portuguese engineer.

I beg you to inform my colleague that the thermocouple element alloys compositions he wants to know are the following:

Alumel: Cr 2%; Ni 98%
Chromel: Cr 10%; Ni 90%

Alumel can also be used as a re-

sistance alloy, its composition being in such case: Al 2%; Fe 0.5%; Ni 94%; Mn 2.5%; Si 1%.

Chromel can also be used as heat resisting alloy having three different compositions:

	Cr	Fe,	Ni
Chromel A	20%	—	80%
Chromel B	15%	—	85%
Chromel C	10%	25%	64%

The composition of thermocouple Chromel corresponds to the so-called Chromel P.

Hoping that my answer will be useful to your reader and begging you to ask him to contact me directly in future cases.

Antonio Joaquim Ferro
Engenheiro
Companhis Unioo Fabrit
Portugal

Editor, I&CS:

In the August 1959 issue of the Reader Inquiry Department #A417, there appears a request for the name of a manufacturer of an ophthalmograph.

A photographic ophthalmograph was at one time made by American Optical Company. I suspect they have discontinued its manufacture since it proved unsatisfactory as a clinical device. Several used models should be available in ophthalmology departments around the country.

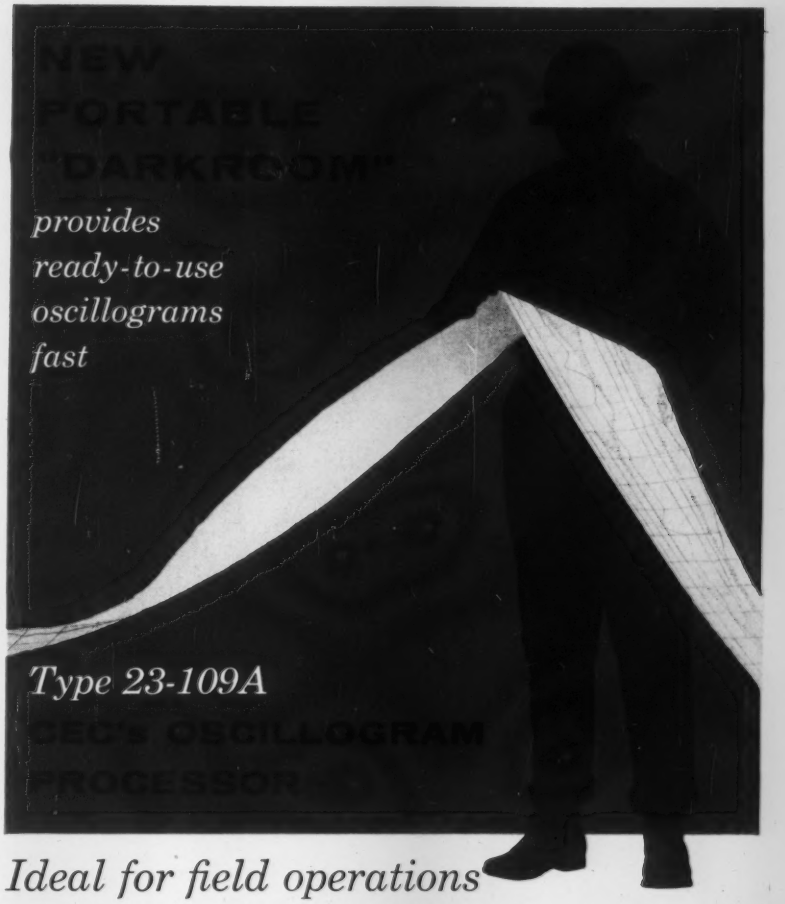
May I also call the inquirer's attention to a book which covers the topic of measurement of eye movement in some detail: *Reading and Visual Fatigue, by Carmichael and Deurborn*, published by Houghton Mifflin Company, 1947.

More recent developments in electronic registrations of eye movements have shifted most oculometric procedures to the use of this type of device. I am enclosing a reprint of an article of my own which you may relay to the person making the inquiry. This article covers the literature on techniques of eye measurement and specifies the use of amplification of the periorbital potentials accompanying eye movement and the registration of these amplified potentials with an oscilloscope and a recorder.

O. Thomas Law, PhD.
University of Michigan
Ann Arbor, Michigan

Editor, I&A:

Your article on "Slide Rules" and Mr. Hunt's article on "The Use of the Slide Rule" were very timely as many of us who have used slide rules for



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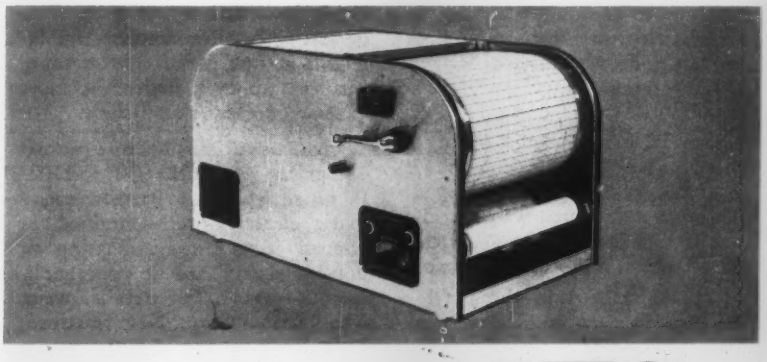

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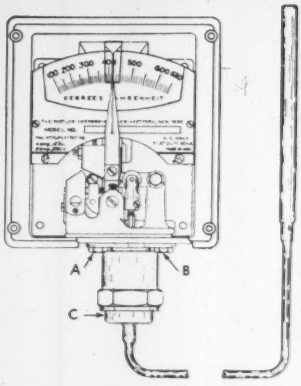
Simplicity in the Partlow, for one thing, means that the control element can be changed *at the job site* in a matter of minutes with no other tool than a screwdriver . . . "Down time" is cut to an absolute minimum!

And simplicity in the Partlow also means the complete elimination of fussy electronic gadgets, delicate levers, hairsprings and other accessories that have a tendency to break down at the first trace of jar or jostle. Partlow controls are famous for their unfailingly accurate performance even under the most adverse operating conditions.

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow pneumatic, electric or self-contained gas control (recording, indicating or non-indicating), to fit your application *precisely*. For details, write The Partlow Corp., New Hartford, New York. Dept. IA-119.



Diagrammatic view of the new MFS reveals "quick-change" feature common to all Partlow controls. In case of damage, merely unscrew at points (A) and (B), and remove element (C) from case. Reverse this process, and your Partlow is ready to resume operation.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

CIRCLE 9 ON READER-SERVICE CARD

Export Ad. Auriema, Inc., 85 Broad St., New York 4, N. Y.

LETTERS—CONTINUED

years become rusty and do not use this versatile tool to its full capacity.

One of the most frequent (and usually very disastrous) errors in slide rule calculations is the misplaced decimal point. Even when carefully approximated, there is chance of this occurring. There is, however, a foolproof method of determining the location of the decimal point:

The number of digits in the answer equals the sum of the digits in the numerator minus the sum of the digits in the denominator. Each digit to the left of the decimal point counts as (+1) and each zero between the decimal point and first figure as (−1). However, when the left C-scale index is on the D scale, one digit is subtracted for each multiplication and one digit added for each division. There is no (o) compensation when the right index of the C scale is on D scale.

Example:

$$\frac{\overset{(3)}{623} \times \overset{(4)}{5970} \times \overset{(5)}{39856} \times \overset{(3)}{139.2} \times \overset{(4)}{7586}}{\underset{(4)}{4283} \times \underset{(4)}{2756} \times \underset{(3)}{492} \times \underset{(5)}{58475}} = 461.$$

623 ÷ 4283	*Left* C scale index on D scale	+1
× 5970	*Left* C scale index on D scale	−1
÷ 2756	*Left* C scale index on D scale	+1
× 39856	Transfer slide to *right* C index	0
÷ 492	*Right* C scale index on D scale	0
× 139.2	Transfer slide to *left* C index	−1
÷ 58475	*Right* C scale index on D scale	0
× 7586	*Right* C scale index on D scale	0

Slide compensation = algebraic sum = 0

Sum of digits in numerator = 3+4+5+3+4 = 19

Less sum of digits in denominator = 4+4+3+5 = 16

Digits in answer = 3

Answer = 461

If the problem had been

$$\frac{\overset{(0)}{.623} \times \overset{(4)}{5970} \times \overset{(2)}{39.856} \times \overset{(-1)}{.01392} \times \overset{(1)}{7.586}}{\underset{(4)}{4283} \times \underset{(4)}{2756} \times \underset{(-2)}{.00492} \times \underset{(3)}{584.75}}$$

Slide compensation same as first example = 0

Sum of digits in numerator = 0+4+2−1+1 = 6

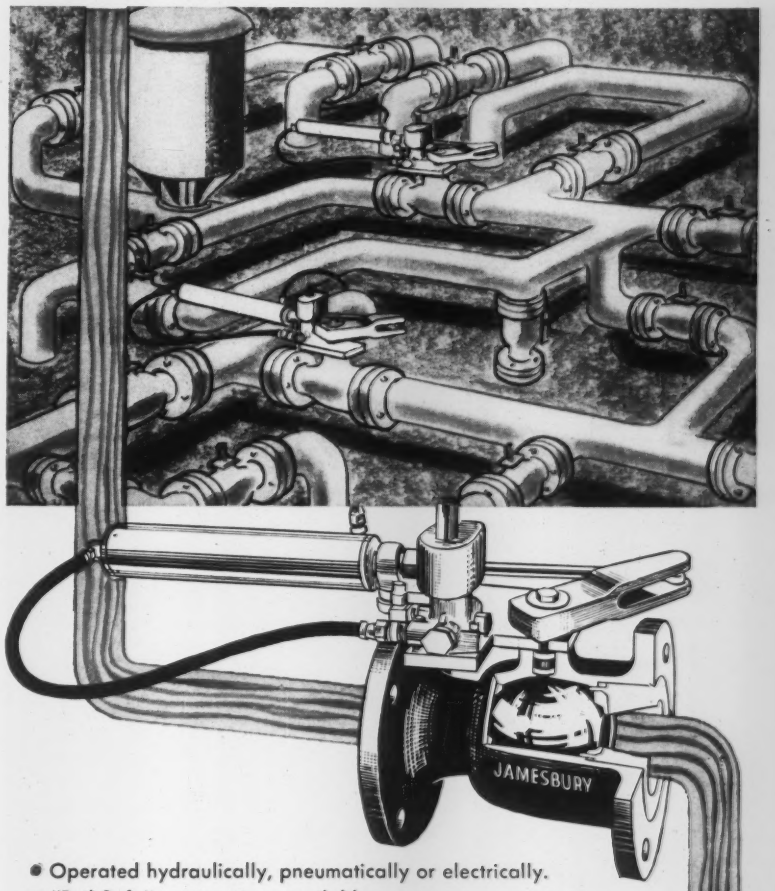
Less sum of digits in denominator = 4+4−2+3 = 9

Digits in answer = −3

Answer = 0.000461

To be positive, the CF/DF scales should be avoided as their use re-

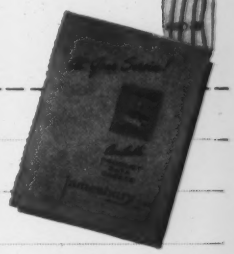
Double-Duty with Jamesbury REMOTE OPERATORS* for "Double-Seal"™ Ball Valves



- Operated hydraulically, pneumatically or electrically.
- "Fail-Safe" constructions available.
- Available as a factory pre-tested unit for *all* Jamesbury "Double-Seal" Ball Valves: from high vacuum to 4500 p.s.i.

*Standard speed for closure: less than ¾ of a second.
Faster speeds available on request.

Distributors In Principal Cities.
Get The Complete Facts On All Jamesbury Products.



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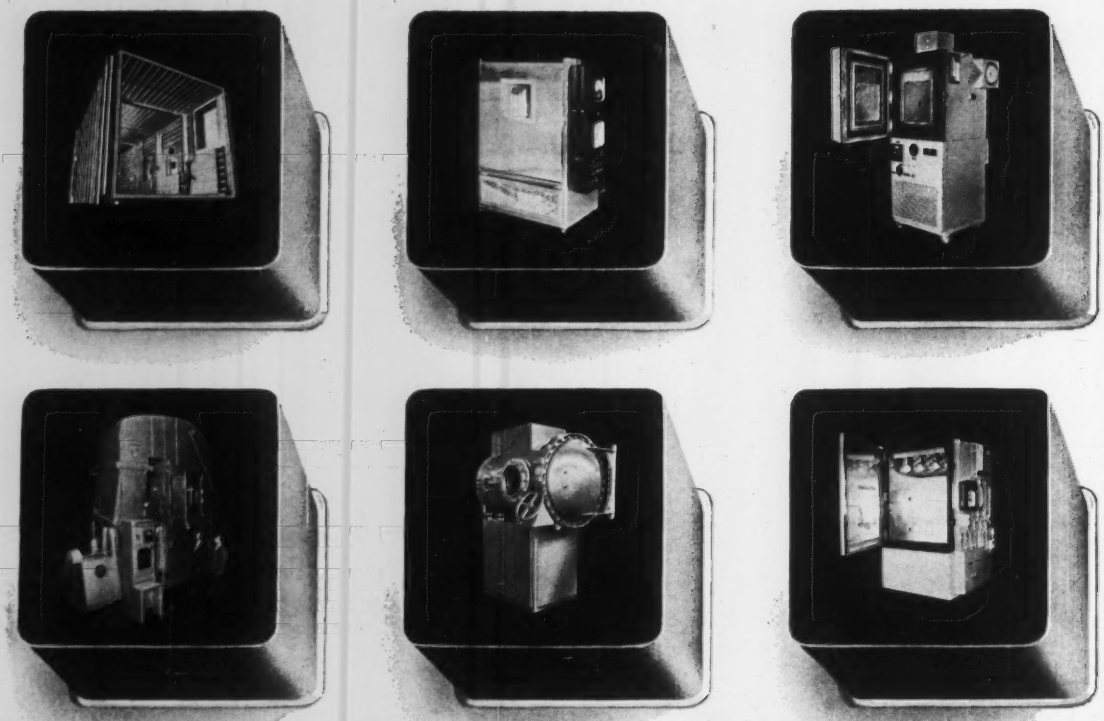
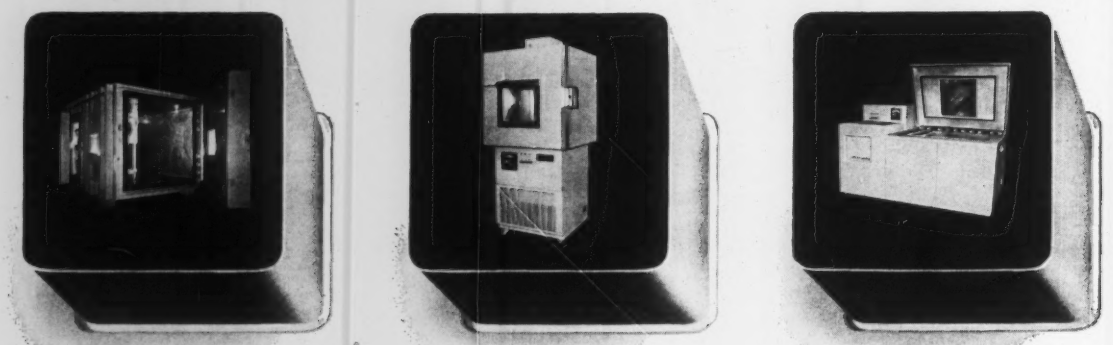
CIRCLE 10 ON READER-SERVICE CARD



Tenney push-button environments



. . . any size, any shape, anytime!

No matter what environmental test chamber you need, this much is certain: Tenney either has it in stock or can adapt one of its proven prototypes. From chambers that could house a family of four, down to refrigerator size (and everything in between), you're sure to find the modern, push-button unit you need.

Altitude, temperature, humidity, explosion, sand, dust, fog—just about every punch nature can throw—can be simulated, either alone or in combination. And you get accurate simulation, complete control and precise measurements every time.

For a complete catalog, describing the entire line, write today to Tenney—the world's largest, most experienced creator of environmental test equipment.

Ask about Tenney's research and development, engineering consultation and design services.

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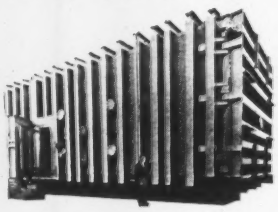
OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT



CIRCLE 11 ON READER-SERVICE CARD

LETTERS—CONT.

verses the rule in most, but not all, cases. However, the inconvenience with the C and D scales of changing the slide to the other end is offset by the time saved in determining the decimal. With practice in choosing the succession of multipliers and dividers, the slide can remain with the right C index on the D scale most of the time so that little compensation is necessary.

J. W. Strickland
The Stearns-Roger Mfg. Co.
Denver, Colo.

Editor I&CS:

Your Reader Inquiry A-379, (March '59) concerns a metal detector sought by a Dutch Co. We suggest he contact: Projecto, Prinsengracht 530, Amsterdam, Holland, for details in the "CINTEL" Electronic Metal Detector; manufactured in England by Rank Cintel, Ltd., and represented in the U. S. A. exclusively by us.

F. S. Royce
Potter Engineering Corporation
Union, N. J.

We publish these letters with interesting international implications.

reader inquiries

Relays for Printed Circuits

Swedish instrument manufacturer seeks suppliers of relays for printed-circuit applications. A-438

Wire Straightening Equipment

Engineer with transistor manufacturer seeks suppliers of equipment to straighten leads for small-type capacitors, resistors, etc. A-437

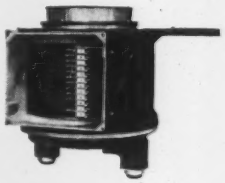
Seismograph

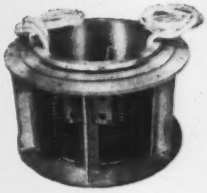
Instrument manufacturer in South Africa seeks sources of supply for seismograph used by building contractors, in road building, etc., which uses "the impact of a hammer blow on the surface of the ground reflected back to the instrument" to record "the condition of the earth immediately below the point of impact." A-436

Color ITV

Assistant comptroller of manufacturing company seeks addresses of firms that can supply color TV, possibly utilizing sequential color principle, for an intended industrial application. A-435

BREEZE SLIP RINGS





In circuitry where slip rings must function with dependable precision and stand up under difficult operational conditions, BREEZE slip rings will do the job.

From 2-ring to 500-ring assemblies . . . currents as high as 350 amps continuous at 220 volts and 700 amps overload at 220 volts. Special high voltage designs available; radio frequency assemblies . . . high speed rotation for thermocouple and strain gage applications. Also segmented ring assemblies for accurate sequencing and timing.

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BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS • GENERATORS • STARTERS
STARTER GENERATORS • BELLOWS • SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING
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CIRCLES & SPECIAL SHAPES

Experimental and Production Blowing
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Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contract Cutters of Tube and Rod.

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SURE

Specify the Finest Digital Voltmeter Made

NLS SERIES 20

When the combination of reliability, speed and accuracy is of uncompromising importance — you can't afford to gamble on "second best" digital measuring equipment! NLS Series 20 instruments are field-proven in the most critical applications — missile and electronic systems checkout, automatic process monitoring, sophisticated laboratory research. Be sure — specify NLS Series 20, the instruments selected by major missile manufacturers after thousands of hours of competitive life testing.

Features: M24 measures DC voltage, voltage ratio or resistance in a third of a second, V24 measures DC voltage and voltage ratio at same speed . . . both instruments feature advanced transistorized circuitry and mercury-wetted relays with life in excess of 3 billion readings . . . ±one digit accuracy on DC voltage and voltage ratio . . . completely automatic operation . . . plug-in modular construction . . . AC or low level measurements with plug-in accessories . . . output connectors for continuous data logging, remote ranging. Ranges: DC voltage ±.0001 to ±999.9; DC voltage ratio to ±.9999; resistance .1 ohm to 1 megohm. Write today for complete data.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR (SAN DIEGO), CALIFORNIA

NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

CIRCLE 14 ON READER-SERVICE CARD

trends

Total market for flow primary elements is about $20 million/year, says C&EN, Oct. 5, 1959. Magnetic flow element sales are increasing nicely, with Foxboro, Fischer & Porter and Hays now producing these elements.

Noise meter market is now at $1-million annual level, says Electronics, has doubled in three years; should double again in three. Anti-noise action in cities has spearheaded growth.

Survey of computer market by Computers & Automation has resulted in 290 reader responses indicating that the 290 companies will spend $500 million to $900 million in next five years. Using arbitrary sampling figure to 10, the market is estimated at "between 5 billion and 9 billion dollars over the next five years."

Federal expenditures for rental of electronic computers and data processing systems will be about $50 million in 1959, compared to $30 million in 1957.

Analog computer market in 1958 was $9.1 million at factory prices, representing 267 sales, says Bureau of Census, Facts for Industry Report on Office, Computing and Accounting Machines.

Electronic Production Resources Agency says market for microwave tubes in 1958 was about $100 million. Market for other microwave components is estimated to be $200 million. Point-to-point microwave equipment market is estimated for 1959 at $40-$50 million, about half military and half industry. However, military sales are expected to increase rapidly.

American Standards Association reports that there are about 130 manufacturers of relays in US, doing an estimated billion dollar business.

Valve market is $1.5 billion, says Business Week, of which ball valves have passed $7 million per year. Ball valve market is predicted to reach $34 million by 1963 (including 14 million military) by "independent research outfit."

Steel industry will spend $28 million in 1959 for instrumentation, reports Fairchild News Service.

Electrical industry, now $20 billion per year, should increase to $44 billion by 1966, $90 billion by 1976, says R. J. Cordiner of GE. GE has invested more than $20 million in lab facilities since 1945, and R&D work at GE is now running at $250 million annually.

Benelux countries (Netherlands—11 million people, Belgium—9 million people; Luxembourg—320,000 people) imported $7 million of US instruments (15% of US sales to Western Europe) in period 1955-58, says BDSA, Dept. of Commerce.

news

Chemical Plant Uses Data Loggers

PITTSBURGH, PA.—Hagan Chemicals & Controls, Inc., has furnished Kybernetes electronic data processing and temperature monitoring equipment for the new

by-products processing plant of Petroleum Chemicals, Inc., and Calcasieu Chemical Corp., at Lake Charles, La. Data logger shown is located in the ethylene plant (the world's largest) and monitors some 500 variables, logging 180 of them every half hour. The temperature monitor in the nearby ethylene oxide plant continuously scans 345 variables, sounding alarms when temperatures exceed preset safety limits.

CIRCLE 156 ON READER-SERVICE CARD

Nylon-Tubing Air Control System Cuts Plant Costs

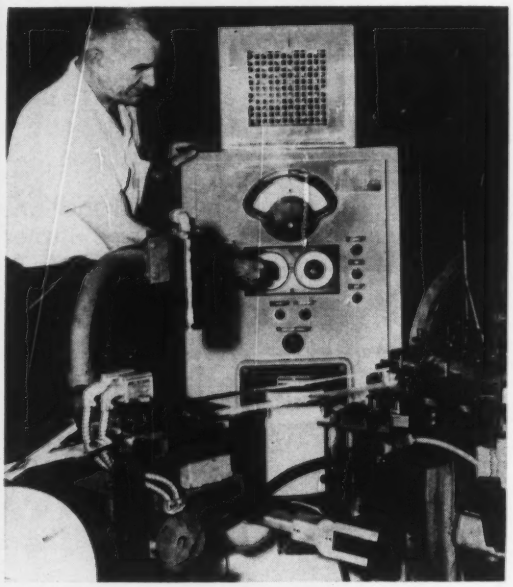
NEW YORK, N. Y.—The National Aniline Division's Hopewell, Va. plant of Allied Chemical Corporation recently completed a unique instrument-air control system utilizing over 100,000 ft of tubing made of Plaskon nylon. The company reports that reduced installation time and material cost resulted in an overall saving of $30,000 over comparable copper tubing installations.

A unique feature of the Hopewell job was the elimination of all intermediate fittings by installing the nylon tubing in continuous lengths from centralized instrument panels to field instruments and valves. All piping was done on the job, with the maximum run being 325 ft. Raw material for the tubing, which is extruded in continuous coils up to 1,000 ft, is made by Allied Chemical Corp.'s Plastics and Coal Chemicals Div., 40 Rector St., New York 6, N. Y.

CIRCLE 157 ON READER-SERVICE CARD

X-Ray Thickness Gage Protects $7.5 Million Metal Investment

NEWARK, N. J.—A portable non-contact XactRay x-ray thickness gage, manufactured by the Industrial Gauges Dept. of Daystrom, Inc., protects an annual $7.5 million investment in copper and brass at the Blackstone Corp., a leading manufacturer of automotive radiator and heater cores.



During production, measurement tolerance on fin copper coiled strip material must be held to 0.0025″ and 0.003″ ±10%. This critical tolerance must be maintained on strip running through forming presses at 160 to 200 ft/min. The material is used to form radiator and heater fins. Critical tolerance on brass used for radiator tubes must be held to 0.005″ with the same 10% deviation specified for the copper stock. Working with these close tolerances, it is essential that measurement gaging be pin-pointed with unquestionable accuracy if costly "downtime" and damaged stock is to be avoided.

In operation more than 15 months, the portable non-contact x-ray gage not only has supplied reliable and accurate measurement data, but has performed efficiently to maintain Blackstone's capacity to produce more than 5,000 radiator cores and 12,000 heater cores daily. Chrysler, Ford, Checker Motors, Willys, and Eaton Mfg. are other users of x-ray thickness gages.

CIRCLE 158 ON READER-SERVICE CARD

It's four instruments in one...

1 dc null detector

2 micromicroammeter

3 microvolt level dc amplifier

4 microvoltmeter

...and can really take a beating

KIN TEL'S ELECTRO-GALVO SOLVES ALL YOUR LOW-LEVEL DC MEASUREMENT PROBLEMS

Sensitive

Functionally equivalent to suspension galvanometers, but with far greater versatility, the Model 204A is the ultimate for DC null detection in low-level bridge and potentiometer circuits. KIN TEL's chopper-stabilized, all-transistor design provides extreme sensitivity and rugged durablity superior to conventional moving coil or electronic galvanometers.

Rugged

Immune to overload and shock, the current sensitivity of the Model 204A is 20 times greater than the sensitivity of high-quality, mechanical current galvanometers. As a voltage galvanometer, the extremely high-power sensitivity of the Model 204A makes it superior to low-impedance moving coil instruments.

Versatile

This reliable, general purpose unit is ideal for use as a direct reading indicator for strain gauge, thermocouple and other current or voltage measurements in industry or laboratory. The 204A's simplicity of operation makes it the key to efficient production-line testing. Its unequalled stability makes it ideal for low-level DC amplification to extend the range of recording and other measurement instruments.

Check these outstanding specifications

- 20 Micromicroamps Per Division Sensitivity
- ±10 Microvolts to 10 Volts or ±0.001 Microamp to 1 Milliamp Full Scale Sensitivity
- Withstands Extreme Overload with No Zero Offset
- Transistorized—Rugged—Insensitive to Shock, Microphonics, Position
- Floating Input
- 7 Voltage or Current Ranges
- 10,000 Ohm Input Resistance
- 10^{-14} Watts Full Scale Power Sensitivity
- Equivalent Built-in Ayrton Shunt—No Accessories to Buy
- Use as Stable DC Amplifier with 1 Volt at 1 Milliamp Output
- Less than 2 Microvolts Drift
- Less than 1 Microvolt P-P Noise

Model 204A Price $425

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

5725 Kearny Villa Road,
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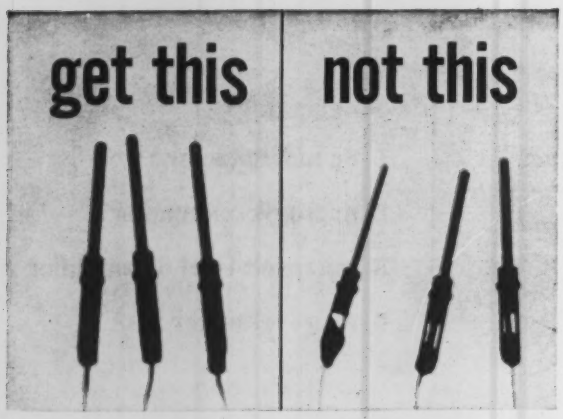
CIRCLE 15 ON READER-SERVICE CARD



Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

Pin No.	Conduction Method: Length of void	Conduction Method: % of void	Resistance Method: Length of void	Resistance Method: % of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

IDEAL INDUSTRIES, Inc. 1420-K Park Ave., Sycamore, Ill. (IDEAL)
Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.
Name_____
Company_____
Address_____
City_____ Zone____ State_____

CIRCLE 16 ON READER-SERVICE CARD

NEWS —CONTINUED

Gas Firms Use Computers To Streamline Service

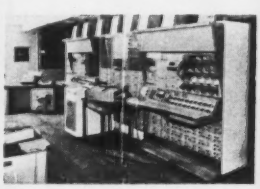
LOS ANGELES, CALIF.—Two large gas transmission companies recently disclosed that they are using electronic computers to design pipe line systems within minutes and to predict natural gas consumption one day before it reaches the customer.

The companies, Texas Gas Transmission and Transcontinental Gas Pipe Line Corporations, are using medium-sized Bendix G-15 digital computers which can tell which compressors fall below expected output, or where new facilities are needed to increase pipe line system service. Weather data and gas consumption statistics available today also are fed into the electronic devices to predict how much gas the customers will be using tomorrow. The computers are made by Bendix Aviation Corp., Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

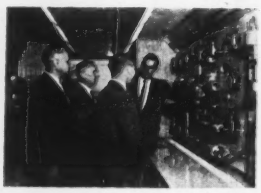
CIRCLE 159 ON READER-SERVICE CARD

FOURTH EXCHANGE CONFERENCE of Bendix G-15 users was held in September and heard the keynote speaker *Stanley M. Humphrey* express his opinion that there will be no immediate radical changes in computer technology. New equipment included the Intercard System for the G-15 and CA-2 card coupler using 1 to 3 MTA-2 magnetic tape units and card punching, reading, and tabulating equipment, introduced by North American Aviation Missiles Div.; and some new accessories.

ELECTRONIC ASSOCIATES has sold the sixth PACE Analog Computing System in England through its European Office. It will be installed at Harwell for the U.K. Atomic Energy Authority. This brings to 35 the number of PACE system sold by E.A.I.'s European Division. Picture shows present temporary installation at Winfrith Heath.



Pace Computer



R-F Display

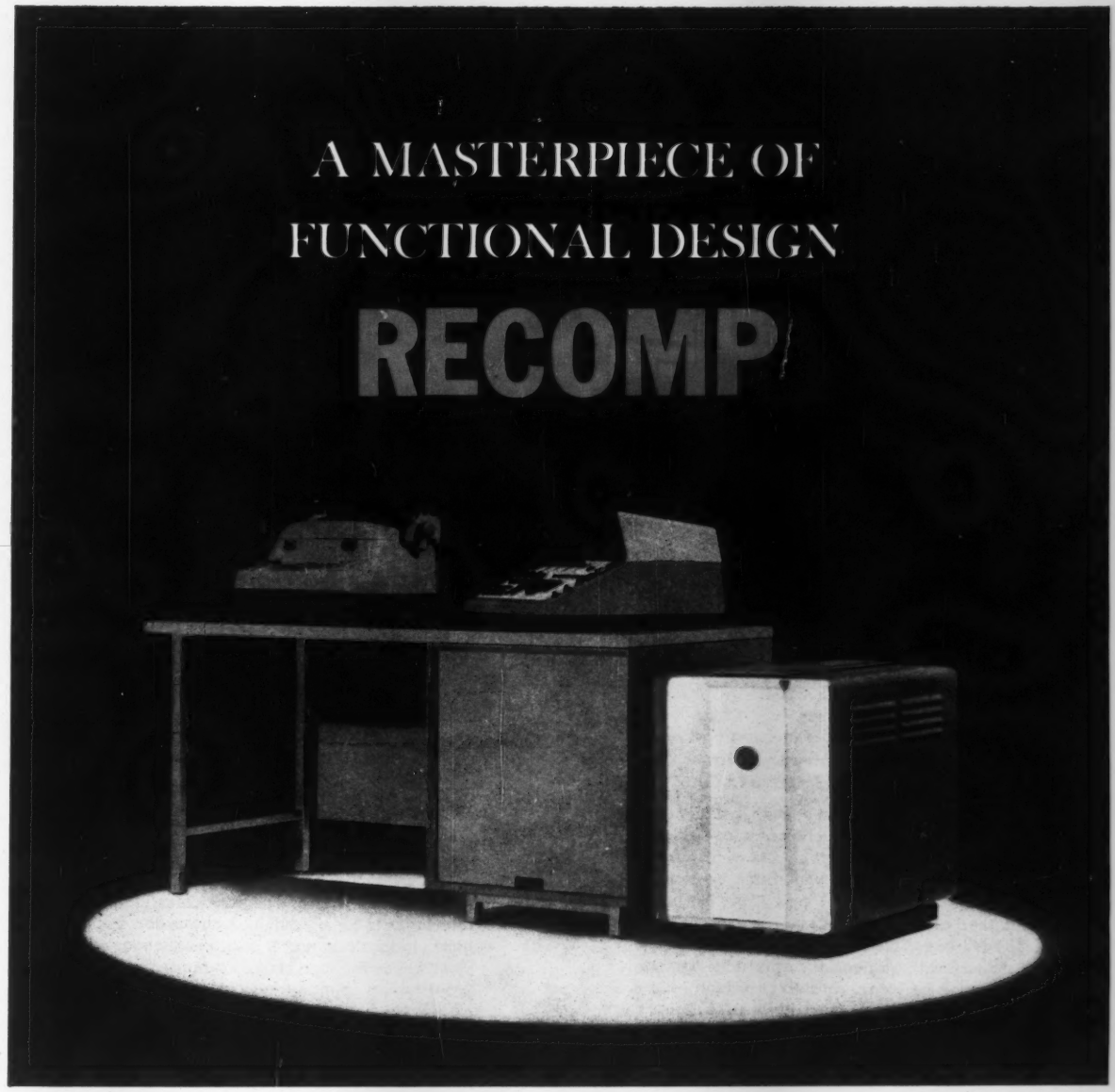
ROBERTSHAW-FULTON's Fulton Sylphon Div. has a bus on the roads of the Eastern States displaying virtually all items produced by the division, ranging from temperature and pressure controls to bellows and assemblies.

CUE (Cooperating Users' Exchange) is a new organization which was formed recently in Boston by users of the Burroughs 220 electronic data processing system.

AMERICAN STANDARD ASSOCIATION (ASA) revealed that a committee is being set up under its procedures to study the possibility of establishing a standard coding and indexing system for machine searching of technical and scientific information.

A MASTERPIECE OF FUNCTIONAL DESIGN

RECOMP



COMPACT...VERSATILE...EASY TO OPERATE

The RECOMP computer strikingly demonstrates the four basic principles of design excellence: performance, ease of operation, ease of maintenance, functional styling. It is a masterpiece of practical design.

The magnetic disk memory contains 4096 words, each of 40-bit length, or 12 decimal digits, eight alpha characters, or two program instructions. It retains as many as 8000 instructions or stores more than 49,000 decimal digits of data. Reading speed of the photoelectric tape is 400 characters a second. The exclusive digital readout flashes arabic numerals to reveal contents of any word or register.

RECOMP gives you far more capacity, versatility, and trouble-free service for your money. It's available now—for outright sale or at a moderate monthly rental that includes maintenance. *And there's no extra equipment to buy...no cost of installation.* For information on how RECOMP can solve *your* problems, write Autonetics Industrial Products, Dept. 611, 3584 Wilshire Boulevard, Los Angeles 5, California.

Digital computers by Autonetics

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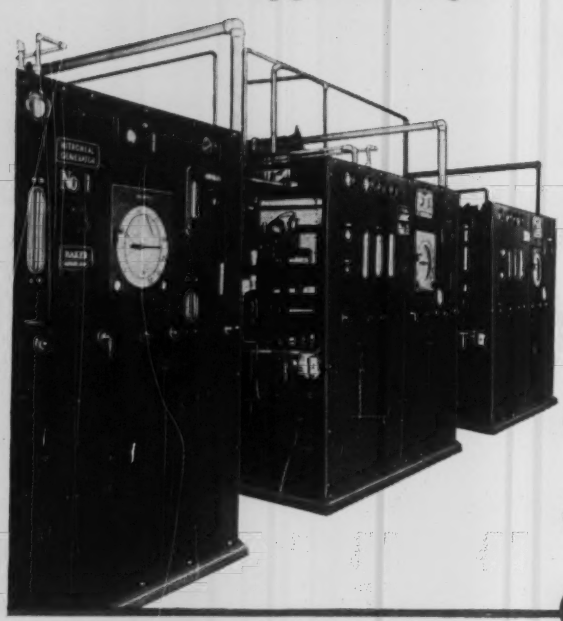
Other Offices: New York, Chicago, Washington, D.C.

CIRCLE 17 ON READER-SERVICE CARD

for the most efficient production of oxygen-free gas



NITRONEAL® GAS GENERATOR

. . . provides by far the most economical and efficient method for the production of pure nitrogen —*completely free of oxygen*—and with hydrogen content precisely controlled at any desired percentage between 0.5% and 25%. Nitrogen is supplied at a fraction of cylinder supply cost.

The Nitroneal Generator is automatic except for startup, with no need for operating personnel. The unit performs instantly, efficiently anywhere in the range of from 25% to 100% of rated capacity. Installation requires only a 110 volt line, water, air, ammonia lines and drain facilities. Units can be supplied in capacities of 100 cfh to 10,000 cfh. . . . The catalyst lasts indefinitely—maintenance costs are practically nil. Write for complete catalog material and data.

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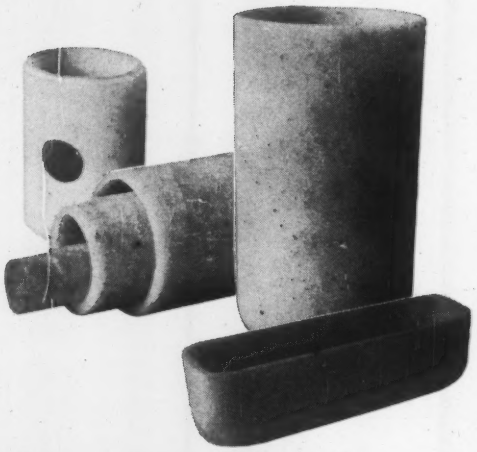
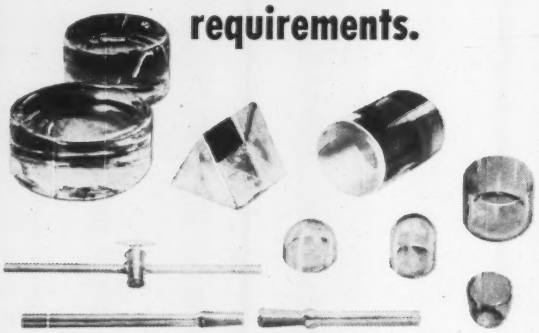
NEWARK, N. J.



look to Amersil for all high purity fused quartz requirements.



Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission applications, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements. Send for bulletin.

AMERSIL QUARTZ DIVISION • 685 RAMSEY AVENUE
HILLSIDE, N. J.

CHEMICAL DIVISION

WRITE FOR LITERATURE

AMERSIL QUARTZ DIVISION

DOMESTIC DIVISIONS: AMERICAN PLATINUM & SILVER DIVISION, AMERSIL QUARTZ DIVISION, BAKER CONTACT DIVISION, BAKER DENTAL DIVISION, BAKER SETTING DIVISION, BAKER PLATINUM DIVISION, CHEMICAL DIVISION, EAST NEWARK INDUSTRIAL CENTER, HANOVIA LAMP DIVISION, HANOVIA LIQUID GOLD DIVISION, IRVINGTON-BAKER REFINING DIVISION, D. E. MAKEPEACE DIVISION, NATIONAL ELECTRIC INSTRUMENT DIVISION, RESEARCH AND DEVELOPMENT DIVISION, H. A. WILSON DIVISION. COMPANIES ABROAD: ENGELHARD INDUSTRIES OF CANADA, LTD. TORONTO, ENGELHARD INDUSTRIES OF QUEBEC, LTD. MONTREAL, ENGELHARD INDUSTRIES, LTD. LONDON, ENGELHARD INDUSTRIES A. G. ZURICH, ENGELHARD INDUSTRIES PTY., LTD. MELBOURNE, SOCIEDAD SURAMERICANA DE METALES PRECIOSOS S. A. BOGOTA, INDUSTRIE ENGELHARD S. P. A. ROME, ENGELHARD INDUSTRIES OF SOUTHERN AFRICA, LTD. JOHANNESBURG. ASSOCIATED COMPANIES: ACME TIMBER INDUSTRIES LTD., SOUTH AFRICAN FOREST INVESTMENTS LTD., SOUTH AFRICA, AZOPLATE CORPORATION, CHARLES ENGELHARD, INC., NUCLEAR CORP. OF AMERICA, INC., U.S.A.

CIRCLE 18 ON READER-SERVICE CARD

CIRCLE 19 ON READER-SERVICE CARD

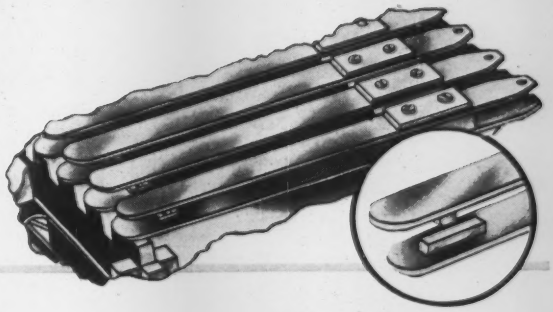
a simplified mirror-bright silver plating process

Here is the most efficient, simple procedure to protect electrical electronic and lamp components with a mirror-bright silver finish—through a complete range from flash to heavy deposit. The procedure is easy, economical and non-critical—with little or no polishing required. Silva-Brite is a clear, water-white solution, enabling the operator to observe work as it is being plated. Uniformly good results are attained with current densities ranging from 10 to 40 amperes per square foot. Normal room temperature operation minimizes fumes and tendency toward bath decomposition. Send for descriptive data together with detailed plating procedures.

AMERICAN PLATINUM & SILVER DIVISION
231 N. J. RAILROAD AVENUE, NEWARK, N. J.

AMERICAN PLATINUM & SILVER DIVISION

CIRCLE 20 ON READER-SERVICE CARD



ECONOTAPE crossbar contacts are most efficient for electrical relays

You can now get ideally efficient crossbar contacts for your electrical relays—with as many contacts as you need, where you need them—with positive assurance of full, contact surface. This has been made possible through the development of Makepeace's new ECONOTAPE, a precision-drawn shaped or rectangular contact wire in either solid precious metal or in laminated metal—in your choice of gold, platinum, palladium, silver and their various alloys.

Econotape crossbar contacts are supplied complete, attached to Makepeace blades . . . attached to blades supplied by you . . . or Econotape for your own attaching.

Econotape is cut off and welded to the blade in one operation. It is no longer necessary to handle and attach individual button type contacts. Positioning of Econotape on the blade is done automatically as the tape is cut off and welded. Permanent attachment is assured by a homogenous metallurgical bond that is undisturbed by expansion and contraction caused by temperature changes.

If you are designing a new relay or trying to cut the cost of your present mechanism, send for Econotape Crossbar Contact literature.

D. E. MAKEPEACE DIVISION • PINE & DUNHAM STREET
ATTLEBORO, MASS.

D. E. MAKEPEACE DIVISION

CIRCLE 21 ON READER-SERVICE CARD

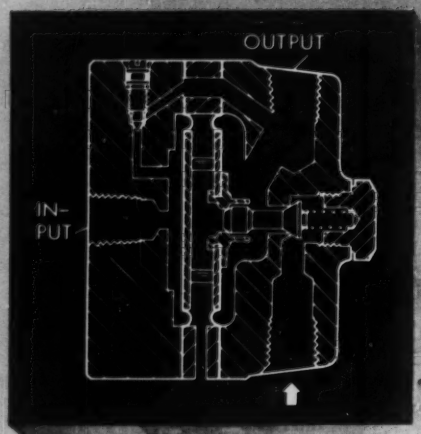
ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

113 ASTOR STREET • NEWARK 2, NEW JERSEY

Another solution to valve problems . . .

MOORE F/R (FREQUENCY-RESPONSE) BOOSTER



Improves stroking speed

and frequency response

5 times or more

Includes a specially designed stabilizing needle valve which permits "tuning" the actuator-positioner-booster circuit for optimum response with stability. Easily added to any "problem" valve.

Write for Bulletin or ask your valve manufacturer.

MOORE PRODUCTS CO.
PHILADELPHIA 24, PA.

ATLANTA, BOSTON, CHARLOTTE, CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, LOUISVILLE, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH.

***In Canada:* Moore Instrument Co., Ltd.**
TORONTO, MONTREAL

Manufacturers of NULLMATIC Pressure Regulators, Transmitters, and M/P Indicating and Recording Controllers.

CIRCLE 22 ON READER-SERVICE CARD

Pushbutton Water Treatment Plant Begins Operation

PHILADELPHIA, PA.—Nerve center of Philadelphia's new $25-million Torresdale filtration plant, world's largest automatically controlled water treatment facility, are 48 instrumented consoles that automatically program the cleaning of 94 rapid sand filters. Consoles are part of a $500,000 instrumentation system application engineered by Minneapolis-Honeywell's Brown Instruments Division,

(Wayne and Windrim Aves., Phila. 44, Pa.) Automatic cleaning of a filter is done in 30 minutes by one operator, compared with three to six days for a prison crew of 15 to 20 men who manually cleaned a slow sand filter in old treatment plant.

Hundreds of pneumatic and electronic devices are interlocked in an intricate network to provide pushbutton operation in treating a normal daily flow of 282 million gallons and a maximum output of 423 million gallons of water.

The controls proportion the rate of chemicals added to the raw water, automatically program the cleaning of 94 rapid sand filters which give the treated water a final "polishing," and regulate final chemical treatment before the water is fed to storage reservoirs for pumping into distribution mains.

CIRCLE 160 ON READER-SERVICE CARD

New Strain Gage Techniques

COLUMBUS, OHIO.—Two unusual techniques for obtaining strain measurements were recently described by Nelson A. Crites, an instrumentation specialist at Battelle Memorial Institute, Columbus, Ohio. One technique permits accurate measurement of strain for indefinite periods in equipment immersed in boiling water; the other is for making strain measurements at critical points in mated mechanical parts.

To protect a strain gage used in boiling water, the gage is housed in a brass blister-type pod, about the size of a quarter, that is soldered to equipment under study at a point where strain measurement is designed. Wires leading from the pod are enclosed in a stainless steel sheath.

To use strain gages for measurements in closely fitted parts, the gage is placed in a shallow groove cut in one of two mated parts, such as a drive shaft. Epoxy resin is used to insulate the gage and fill in the groove before the mated parts are assembled for study.

news

Radioactive Gas is Used to Test Hermetic Seals

PRINCETON, IND.—A new leakage detection system for automatically and non-destructively testing hermetically sealed relays on a mass production scale is being used by Potter & Brumfield, the relay manufacturing division of American Machine & Foundry Co.

This new system, the Radiflo, built by American Electronics, Inc., uses a non-toxic, inert radioactive gas (Radene III).

The relays are exposed to the gas under pressure for a prescribed "soaking time." After that an air washing process removes all radioactive material from the external surfaces. Relays with leaks retain tell-tale gamma radiation. Production workers can now perform a simple go-no-go test using a scintillation counter. Details are avaliable from Potter & Brumfield, Princeton, Ind.

CIRCLE 162 ON READER-SERVICE CARD

THOMPSON-RAMO-WOOLDRIDGE PRODUCT CO. will deliver a $175,000 control and data reduction system utilizing an RW-300 Digital Control Computer to Sperry Utah Engineering Laboratory in conjunction with its environmental test facilities for the Sergeant missile.

CIRCLE 163 ON READER-SERVICE CARD

INDIANA STEEL PRODUCTS recently announced an important new break-through in the field of high-energy permanent magnets: Hyflux Alnico V-7, the first commercial permanent magnet to produce energy values of 7 million. Residual induction and coercive force are also substantially greater than in hither to known materials.

CIRCLE 164 ON READER-SERVICE CARD

CONSOLIDATED SYSTEMS announced plans to repeat a Symposium on Pilot Plant Automation that attracted representatives of the nation's leading petroleum and chemical industries this year. The dates are April 7 and 8, 1960.

ILMAC, the International Exhibition of Laboratory, Measurement and Automatic Control in Chemistry, and two congresses in connection therewith, will be held in Basle, the center of the Swiss Chemical Industry, from November 10 through 15, 1959. Thirty lectures by well-known representatives of theoretical and applied science from Belgium, Germany, France, Holland, Switzerland, and the USA, have been planned. By the end of June a total of 200 registrations had been received from exhibitors in Austria, Denmark, Germany, England, France, Holland, Italy, Sweden, Switzerland and the USA.

NEMA and **EIA** recently announced an integrated program in their semiconductor activities in which NEMA will supply technical standards and marketing data for rectifiers and controlled rectifiers, while EIA will cover diodes and transistors generally used in signalling and lowel-level switching applications.

Sub-Min. Widest selection of Pilot Lights - from DIALCO

NEON
T-2 HIGH BRIGHTNESS and REGULAR TYPES

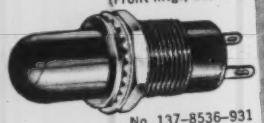
DIALCO's Sub-Miniatures use tiny T-2 Neon Glow Lamps: *NE-2J (High Brightness)* at 105-125 V., A.C.; or *NE-2D* (regular) at 105-125 V., A.C. or D.C.

NEW Series mounts from *FRONT* of panel in 15/32" clearance hole (supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 5 colors; give all-angle visibility. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-159B and L-162.

(Illust. approx. actual size)

(Front mtg., 15/32")



No. 137-8536-931

(Front mtg., 17/32")

No. 145-5036-991

(Back mtg., 15/32")

No. 138-3836-1431-99

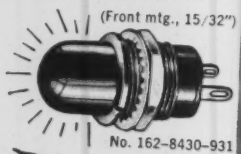
DIALCO

INCANDESCENT
T-1¾ 2-TERMINAL and 1-TERMINAL TYPES

Designed for use with T-1¾ midget flanged incandescent lamps—1.3 V. to 28 V... *NEW* Series mounts from *FRONT* of panel in 15/32" clearance hole—(supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 7 colors. Units are fully insulated; meet applicable Mil. Specs.

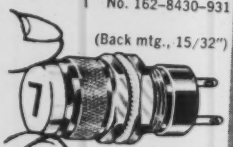
Ask for Brochures L-156C thru 159B, and L-162.

(Front mtg., 15/32")



No. 162-8430-931

(Back mtg., 15/32")



No. 134-3830-375-7

Spring-mounted Lens-with-Message is *rotatable*.

1-Terminal Pilot Lights

For use on *grounded circuits*. Mount in 13/32" or 15/32" clearance hole. Binding screw or soldering terminal.

(Front mtg., 13/32")

No. 101-4630-971

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. ● HYacinth 7-7600

CIRCLE 23 ON READER-SERVICE CARD

Univac Aids Toiletries Manufacturer

NEW YORK, N. Y.—The Mennen Company, a leader in its field, with an extensive line in men's toiletries, baby-care, and family-care products, is using a Univac 120 Punched-Card Computer in a highly integrated data processing system which reveals sales forecasting, production scheduling and reporting, accounts receivable, accounts payable, labor distribution, purchase order reporting and expediting, material cost and inventory to all levels of management. Copy of a folder (U-1760) describing this installation is available by writing to Remington Rand Division of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

X-Ray Diffraction In Industry To Be Strong Control Tool

MILWAUKEE, WIS.—At the eleventh annual Fall X-Ray Diffraction School sponsored by the X-Ray Department of General Electric Company, Dr. David Harker, director, Protein Structure Project, Polytechnic Institute of Brooklyn, predicted that the role of x-ray diffraction for chemical analysis, metallic testing and quality will soon move into the production lines as a full-fledged quality control mechanism.

The GE single crystal orienter was demonstrated under working conditions, showing how complete diffraction patterns can be obtained quickly and accurately. Data are available from GE, X-Ray Dept., 4855 W. Electric Ave., Miwaukee, Wis.

CIRCLE 165 ON READER-SERVICE CARD

SIE (Southwestern Industrial Electronics Co.) announces sale of a CM-2 Analog Computer to Dow Chemical Co., Texas Div., Freeport, for use in efficiency calculations of a power plant.

CIRCLE 166 ON READER-SERVICE CARD

BUSINESS AND DEFENSE SERVICES Administration of the Dept. of Commerce has amended Order M-17 to the effect that manufacturers of power and transmitting electron tubes may now reserve small fixed percentages for commercial orders, set apart from rated (defense) orders.

REMINGTON-RAND recently unveiled its first Univac Solid State computer at its Demonstration Center in Pittsburgh. It is comprised of a central processor, a card reader, a read-punch unit, and a high-speed unit that pours out printed results at the rate of 600 lines/min.

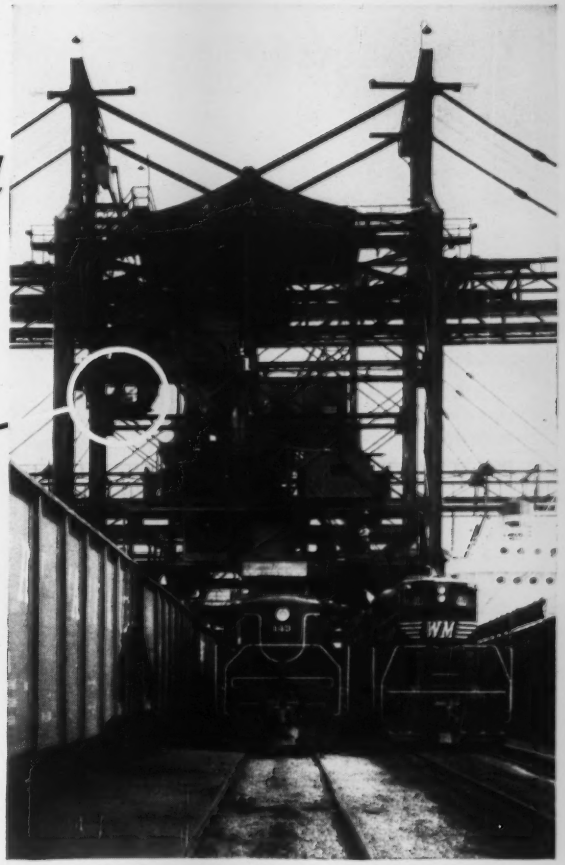
MINE SAFETY APPLIANCES CO., during a four-week training course in instrumentation for representatives of its subsidiaries in Germany, Italy, and Scotland, featured "shirt-sleeve conferences" to provide extensive coverage of general theory, application, and maintenance of its product line.

TEXAS INSTRUMENTS has been awarded a contract for a completely-automated electronic supervisory control system to serve on an offshore gas well production platform of Gulf Oil near Corpus Christi.

CIRCLE 167 ON READER-SERVICE CARD

Automation from crane to customer's office at the Western Maryland

After unloading ore from ship to railroad car, weighman in crane transmits data to yard office for automatic preparation of waybill and other documents.



Teletype Printer in a crane automates ore waybilling

As ore is transferred from ships to railroad cars at Western Maryland's Port Covington docks, a weighman high up in the control cabin of the ore-unloading crane records the lot number, tonnage, and car data on a Teletype Printer. Instantly, this information is reproduced in the yard office in punched tape—starting the automatic writing of waybills by a combination of Teletype page and tape equipment.

The only manual intervention following the transmission of the variable data from the crane is the association of fixed-data tapes by the yard clerk. The entire procedure takes just minutes—so that when the last car is coupled to the train, all waybills, arrival notices, and consignees' copies are ready. Accuracy is improved, too—since mechanization eliminates recopying errors.

As a by-product of waybill preparation, a master tape is punched automatically, which is used to produce a complete shipping statement. The system also enables the Western Maryland to give customers an extra service to speed their own accounting procedures: advance direct wire transmission of shipping statement data by Teletype equipment or a duplicate of the master tape by mail.

This installation is just one example of how railroads today are using Teletype equipment in new, imaginative ways to trim costs, improve service. This unusual application is made practical by the ruggedness built into Teletype equipment, so that it functions dependably and economically even in the dust-generating environment of ore-loading operations. If you would like information on the new Teletype Model 28 Line, please write to: Teletype Corporation, Dept. 23-L, 4100 Fullerton Avenue, Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 24 ON READER-SERVICE CARD

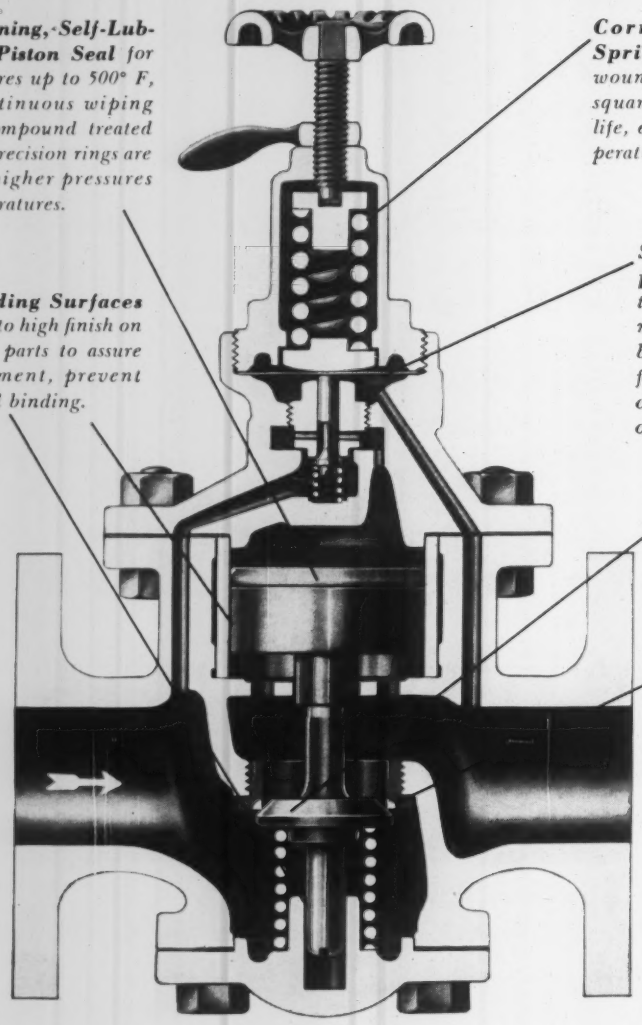
HERE'S WHY YOU GET EXTRA VALUE COMPLETE LINE OF

Self-Cleaning, Self-Lubricating Piston Seal *for temperatures up to 500° F, gives continuous wiping action. Compound treated cast iron precision rings are used for higher pressures and temperatures.*

Corrosion-Resistant Springs *are accurately wound with ends ground square. Maximum spring life, even under high temperature conditions.*

Stainless Steel Diaphragm *responds instantly to any flow change—eliminates stuffing boxes and bellows seals. Diaphragm's full travel is less than its own thickness, can't be over-stressed.*

Long Guiding Surfaces *are ground to high finish on all moving parts to assure true alignment, prevent cocking and binding.*



Single Seated Construction *assures positive dead end shut off.*

Stellited Seating Surface *combined with a hardened stainless main valve provides ultimate in erosion resistance.*

Interchangeable parts *May be replaced without taking valve body off the line, and, even more important, without machining.*

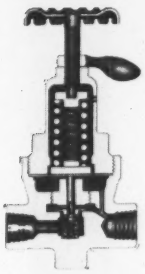
Cutaway of Leslie internal pilot, piston operated reducing valve class LY, shows typical Leslie quality construction features. Throughout the Leslie line, features like these and others presented on the next page are your assurance of lower operating costs and long life performance. They are based on over 50 years of leadership in designing and manufacturing quality regulators.

Internal pilot piston operated reducing valves are available for steam services, up to 2500 lbs., ASA, reduced pressure ranges to 1400 psi. Sizes ½ to 6". Cast iron, bronze, steel or alloy steel construction.

LC-9

CIRCLE 25 ON READER-SERVICE CARD

IN LESLIE'S REDUCING VALVES AND REGULATORS



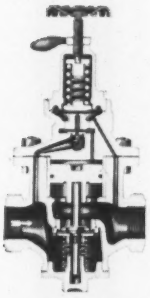
LESLIE SMALL FLOW REDUCING VALVES

Leslie small flow reducing valves are used in pilot plant operations, plastic molding presses, laboratory units, gland sealing, steam sterilization and atomizer units and wherever control of small flows of steam, air, gas or non-corrosive liquids are a problem.

These ½" valves feature simple, direct operated design with screwed or bolted adjusting spring assembly for easy access to the internal parts. No stuffing boxes or fussy seals.

PRESSURE-TEMPERATURE RANGES

BODY MATERIALS AND CONSTRUCTION	CLASS	MAX. INLET PRESSURE PSI		MAX. TEMP. °F.	MIN. PRESS. DROP PSI	REDUCED PRESS. RANGE PSI
		STEAM	COLD LIQUID AIR OR GAS			
BRONZE Screwed Bonnet	LCA	–	400	150	10	5-285
	LCB LCC LCD	300	400	550	10	10-285
	LCLA	–	400	150	10	2-35
	LCLB LCLC LCLD	300	400	550	10	2-35
STEEL Thru-bolted Bonnet	LCL(B)S LCL(C)S LCL(D)S	600	1000	750	10	25-400 10-50



LESLIE REDUCING VALVES FOR AIR OR GAS SERVICE

Leslie internal pilot, piston operated reducing valves offer a combination of accurate regulation and low maintenance service, and are used for accurate control of air or gas with inlet pressures up to 400 psi at 150° F.

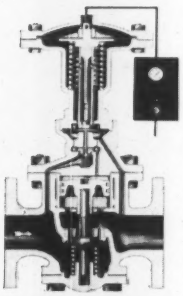
Accuracy of regulation is comparable to instrument control with full flow for equivalent pipe size. Valves feature 99% accuracy of regulation at rated capacity.

Positive, bubble tight shut-off is provided by resilient, single seated valve disc. Fully guided main valve, stainless steel diaphragm and non-corroding internal springs assure long, trouble-free operation.

PRESSURE RANGES AND CONSTRUCTION

CLASS	SIZE (Inches)	MAXIMUM INLET PRESSURE & TEMP.	REDUCED PRESSURE RANGE-PSI		BODY MAT'L	END CONNECTIONS
			MIN.	MAX.		
LA-5 LAE-5	½-4	25-400 psi 150° F max.	5*	285	Bronze	½-2" 300 lb. screwed ½-4", 150 & 300 lb. MSS flanged
LAK LAEK		25-400 psi 150° F			Cast Iron	½-2" 250 lb. screwed 1½-3" 250 lb. ASA flanged
		25-175 psi 150° F max.				1½-4" 125 lb. ASA flanged

*5% of inlet pressure over 100 psi



REMOTELY ADJUSTED REDUCING VALVES

Operating characteristics of Leslie remotely adjusted reducing valves are identical to manually adjusted types. The remotely adjusted reducing valve is adjusted to the desired pressure setting by air pressure from an air loading device. The constant loading force on the upper diaphragm opens the pilot valve and is balanced by a constant reduced pressure proportional to the loading force.

The air loading panel eliminates hazardous or inconvenient adjustments and provides fast means of readjusting pressure to meet changing requirements.

REMOTELY ADJUSTED REGULATING VALVES

TYPE	SIZES AVAILABLE (Inches)	BODY MATERIALS AVAILABLE	INLET PRESSURE RANGES (PSI)	MAXIMUM REDUCED PRESS. (PSI)
Small flow, internal pilot actuated, diaphragm operated	¼, ⅜, ½	Bronze	20-300 psi 550° F steam, 20-400 psi 150° F air	175
Internal pilot actuated, piston operated	½ - 6	Cast Iron Bronze Cast Steel	25 psi up to 600 psi, 750° F	175
Internal pilot actuated, piston operated for high pressure service	½ - 3	Cast Steel and Alloy Steels	300 psi up to 3000 psi	700

For sizing and capacity data on this Leslie line of valves, contact your Leslie engineer or write for Bulletin 5302B.

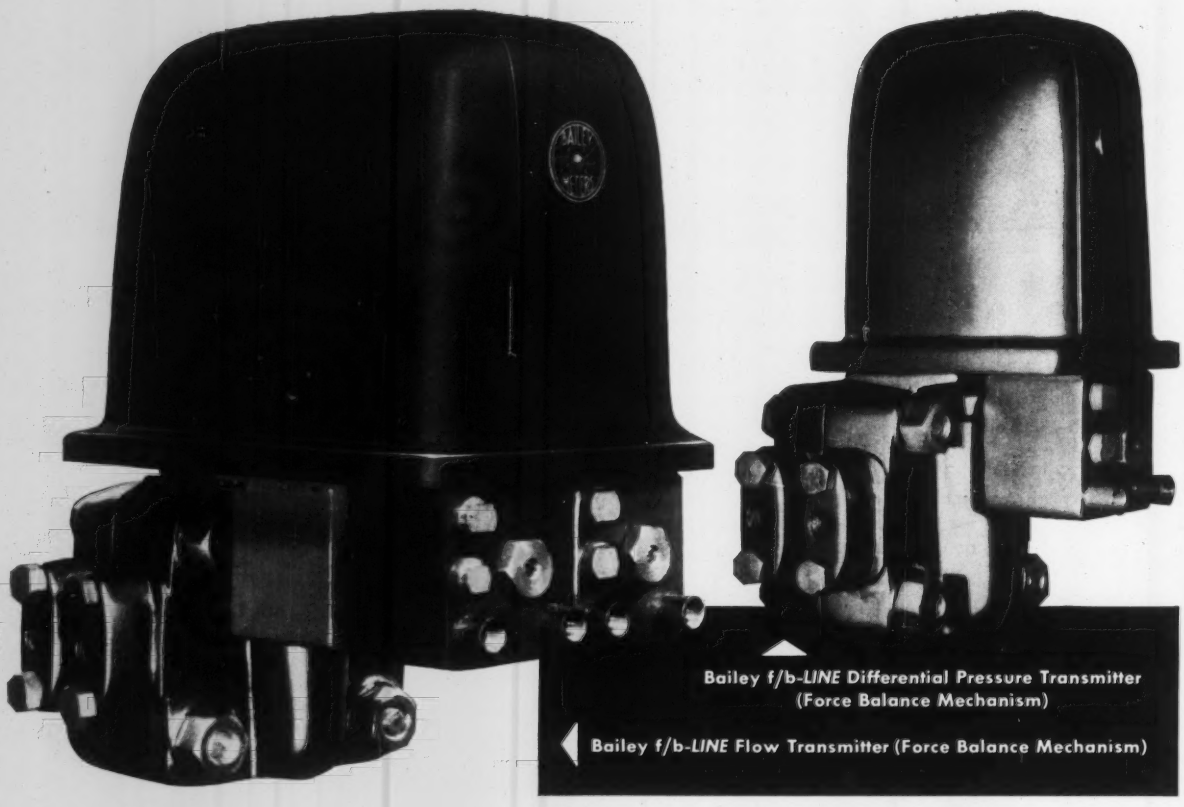
TRADE LESLIE MARK

REGULATORS and CONTROLLERS

Leslie Co.: 499-F Grant Avenue, Lyndhurst, New Jersey

Over 275 Factory-Trained Engineers At Your Service—Nationwide!

CIRCLE 25 ON READER-SERVICE CARD



Bailey f/b-*LINE* Differential Pressure Transmitter (Force Balance Mechanism)

Bailey f/b-*LINE* Flow Transmitter (Force Balance Mechanism)

Two new Bailey *f/b-LINE* Transmitters

permit new accuracy in measuring flow and differential pressure

Pneumatically transmits rate of flow—or differential pressure—measurements to indicating, recording, and/or controlling equipment at remote stations. Transmitters consist of a diaphragm measuring mechanism and a force balance pneumatic transmitting unit.

APPLICATION

For steam, water, air, gases and other fluids producing differentials across primary elements from 0-2 in. H_2O to 0-2000 in. H_2O at maximum service pressure of 50, 1500, and 5000 psig.

FEATURES

Transmits a Signal Directly Proportional to Rate of Flow. Uses receiver with uniformly-graduated chart or scale. Eliminates need for external square-root extractors or characterizers.

10 to 1 Turndown. Differential range of each diaphragm measuring element may be changed by factor of 10 to 1; e.g., 0-20 in. H_2O diaphragm may also measure 0-2 in. H_2O.

Screwdriver Adjustments. Range and zero adjustments readily accessible. Range may be changed with screwdriver adjustment.

Overpressure Protection. Protects against full service pressure applied to either side of diaphragm.

Fast Response. No viscous dampers needed, so speed of response is very fast.

Corrosion Resistant. For maximum differentials between 20 and 2000" H_2O, all parts in contact with process fluid may be stainless steel. No sealing fluids or sealing diaphragm required.

Good Stability. Reset type boosters give good stability with high gain.

Versatile Mounting. May be mounted on process piping, wall, or separate mounting pipe using same bracket.

For additional information, call your local Bailey District Office, or write direct. G46-1

Instruments and controls for power and process

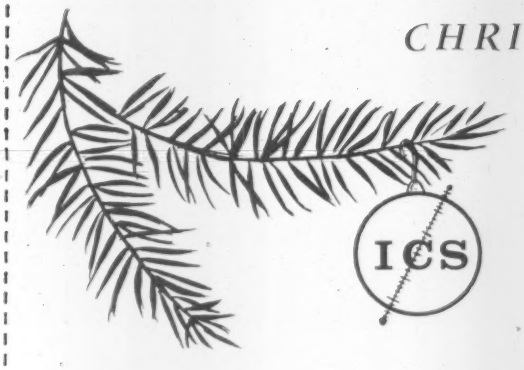
BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 26 ON READER-SERVICE CARD

CHRISTMAS GIFT ORDER FORM



INSTRUMENTS and CONTROL SYSTEMS

CHRISTMAS

GIFT

ORDER FORM

RATES:

For U.S., U.S. Possessions and Canada, special Group Prices apply . . .

A. For 5 or more one-year subscriptions on one order—$2.00 each.

B. For 4 subscriptions on one order—$2.25 per subscription.

C. For 3 supscriptions on one order—$2.50 per subscription.

D. For 2 subscriptions on one order—$3.00 per subscription.

E. Single subscription—$4.00 per year.

For Latin America, price per one-year subscription is $6.00

For other countries, price per one-year subscription is $10.00

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Part of the remarkable success of the G-15 is due to that low price. One user writes, *". . . the nearest competitor to the G-15 costs five times as much."*

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Complete details will be sent upon request. Mention specific problems where the G-15 may be helpful, and we will be glad to advise you.

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CIRCLE 27 ON READER-SERVICE CARD

microflex
RESET TIMER
20 turn dial provides EXACT timing for industrial processes
The double micrometer dial permits 1200 accurate, visual settings over entire dial range. Set this timer for 18 minutes 6 seconds or any other exact time setting required.

Savings

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility

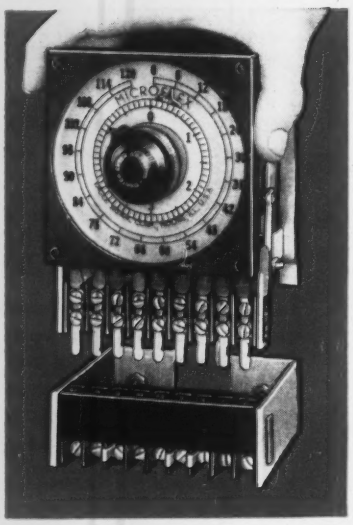
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

Reliability

- Proven reliability in thousands of industrial processes for more than 25 years.



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events

November 23-24

Symposium on Solid State Devices, Philadelphia ISA, AIEE and IRE, Benjamin Hotel, Philadelphia, Pa. Write Frank G. Caveler, Int. Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

November 30-December 4

ASME Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J. For information write ASME Meetings and Divisions Dept., 29 West 39th St., New York 18, N.Y.

November 30-December 4

27th Exposition of Chemical Industries, New York Coliseum, N. Y. For information write Publicity Dept., 480 Lexington Ave., New York 17, N. Y.

December 1-2

Eastern Joint Computer Conference, Statler Hilton Hotel, Boston, Mass. For information write Douglas T. Ross, Servomechanisms Laboratory, Massachusetts Institute of Technology, Cambridge 39, Mass.

December 1-2

Fourth Midwest Symposium on Circuit Theory, Marquette University. For information write Stanley Krupnik, Jr., Assistant Director-Department of Electrical Engineering, Marquette U., Milwaukee 3, Wis.

December 6-7

52nd Annual Meeting of American Institute of Chemical Engineers, San Francisco, Calif. For information write J. Kohl, Tracerlab Inc., 2030 Wright Ave., Richmond, Calif.

January 25-29

Stress Measurement Symposium, on campus of Arizona State University. For information write Strain Gage Readings, 5602 East Monte Rosa, Phoenix, Arizona.

January 26-27

Society of Vacuum Coaters Technical Conference, New York City, N. Y. For information write John Scharnberg, Bee Chemical Co., 1233 S. Stony Island Ave., Chicago 33, Ill.

January 30-February 3

Committee Week for the American Society for Testing Materials, Netherland Hilton Hotel, Cincinnati, Ohio. For information write Fred F. Van Atta, Asst. Sec., A.S.T.M., 1916 Race St., Phila. 3, Pa.

April 6-8

Institute of Environmental Sciences National Meeting, Biltmore Hotel, Los Angeles. For information write Bruno Forscher, 16446 Bircher St., Granada Hills, Calif.

April 19-21

Polytechnic Institute of Brooklyn's Tenth International Symposia, Engineering Societies Bldg., 33 West 39th St., New York City. For information write Jerome Fox, Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.

NEW M-S-A PROCESS REFRACTOMETER

16½" wide x 11¾" high x 12" deep

measures components of organic and inorganic streams in these typical applications:

Acetone in water
Alcohol in water
Ammonium sulfate in water
Benzene in cyclohexane
Benzene in ethanol
Boron chemical processing
Brine concentration
n-Butane in isobutane
Butadiene purity
Citrus juice blending
Cyclohexane in benzene
Cyclohexane separation from normal-hexane
Distillation control
Ethanol in benzene
Ethanol in water
Ethylene glycol in water
Food products
Gasoline additives
Gasoline fractionation
Glycerol in water
Hydrogenation of food oils
Isopropyl alcohol and methyl ethyl ketone in secondary butyl alcohol
Isopropyl alcohol in water
Methanol in water
Monitoring chromatographic columns
Nitric acid in water
Polymerization control
Propylene glycol in water
Separation of aromatics
Sodium chloride in water
Stream blending
Styrene in ethylbenzene
Sugar concentrates
Sugar in water
Sulfuric acid in water
Vinegar production
Water in acetic acid
Water in ethanol
Water in methanol

WHERE TO USE IT

You can use the new M-S-A® Process Refractometer for industrial applications in production or research. This unit controls either stream or batch processes. Measures and controls product quality. Solves a variety of problems requiring rapid, accurate determinations. Conversion to *new* problems is quick and easy. We've listed some typical applications at the right.

PRINCIPLE OF OPERATION

The M-S-A Process Refractometer depends on the differential refraction of light passing through two materials which may have different refractive indexes. It detects and measures the change in light bending due to a variation in refractive index of a "sample" relative to a constant standard. This variation is detected by a Cadmium Sulphide Photocell Circuit.

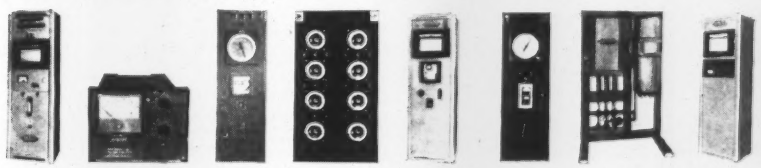
SPECIFICS

This is a high sensitivity instrument: 0 to .005 RI units full scale. Accuracy is ±1% full scale or ±.000005 RI, whichever is larger. Zero drift is 1% full scale or less per day. Response is 90% in 30 to 60 seconds. Sample flow required: 5 to 20 cc/minute. Available in explosion-proof or non-explosion-proof construction. Power needs: 50/60 cps—100 watts—115 volts.

MSA ASSISTANCE

MSA Instrument Specialists, implementing more than 30 years of MSA experience in gas analysis, can help shed some light on your sampling problems. First, perhaps you might like to look over our technical bulletin on the new M-S-A Process Refractometer. We'd like to send you a copy in the return mail. Write, wire, or phone MSA's Instrument Division, Pittsburgh 8, Pa.

Complete Line Instrumentation for Process Stream Analysis



M-S-A® LIRA® Infrared Analyzer Model 200 | M-S-A® LIRA® Infrared Analyzer Model 300 | M-S-A® Inert Gas Analyzer | M-S-A® Combustible Gas Analyzer | M-S-A® Thermatron Analyzer | M-S-A® Oxygen Indicator | M-S-A® Water Vapor Recorder | M-S-A® BillionAire® Analyzer

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Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

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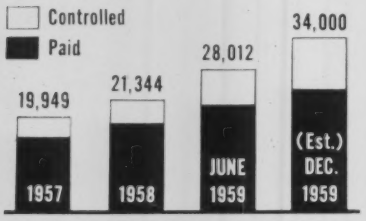

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now there are 3

Honeywell, developers of the original VISICORDER Ultra Violet recording oscillograph principle, now brings you a third great Visicorder oscillograph . . . the

MODEL 1108 24-CHANNEL DIRECT-RECORDING VISICORDER OSCILLOGRAPH

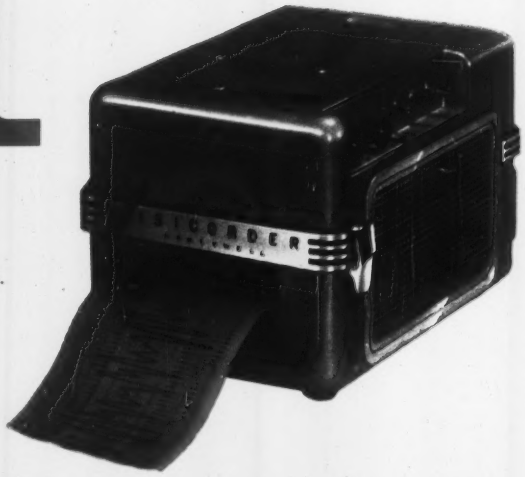
H
HONEYWELL

1

MODEL 906 VISICORDER

The original 8-channel Model 906 Visicorder was the first oscillograph to make use of the now-famous Ultra-Violet Visicorder recording principle, pioneered and developed by Honeywell. The 906 Visicorder was the first oscillograph to combine the high frequency response and writing speed of photographic-type oscillographs with the convenience of direct recording. Recent models incorporate time lines and grid lines, and record up to 14 simultaneous channels of data at frequencies from DC to 5000 cycles per second.

The 906 Visicorder is ideal for uses requiring up to 14 channels of data.



3

THE NEW MODEL 1108 VISICORDER OSCILLOGRAPH

2

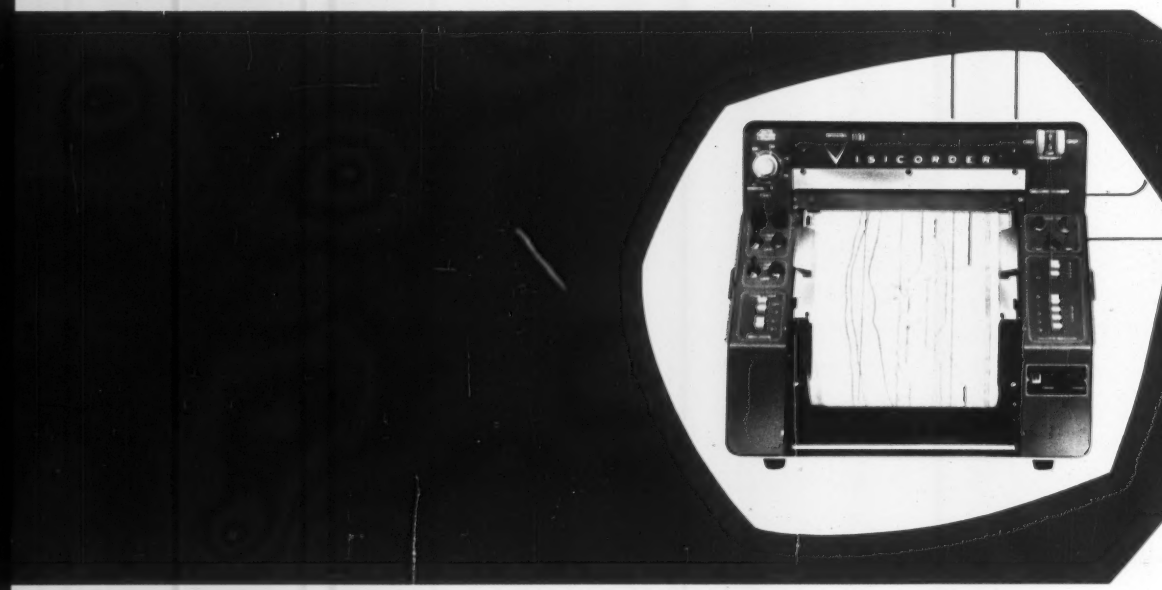
MODEL 1012 VISICORDER

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for converting as many as 36 simultaneous channels of dynamic data into immediately-readable records. Like other Visicorders, the 1012 permits monitoring the information at the recording point as it goes on the record. It also records at frequencies from DC to 5000 cps.

The Model 1012 Visicorder, with its conveniences and broad capacities, is ideal for large-scale uses where up to 36 channels of data are required.

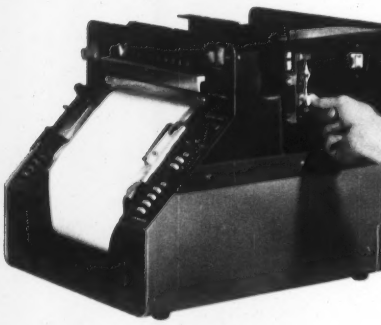
NEW MODEL 1108 VISICORDER provides the ultimate in unlimited variety of applications.

The Model 1108 may be used in direct connection with many types of transducers where high frequency recordings are not required. Or it may be teamed with various types of amplifiers where high-frequency—high amplitude readout is desirable. A broad selection of galvanometers with a wide variety of sensitivities and frequencies is available. A schematic diagram designed to suggest sample hookups for various applications—with and without amplification—appears at lower right, and demonstrates the wide variety of uses to which this one recording system may be put.

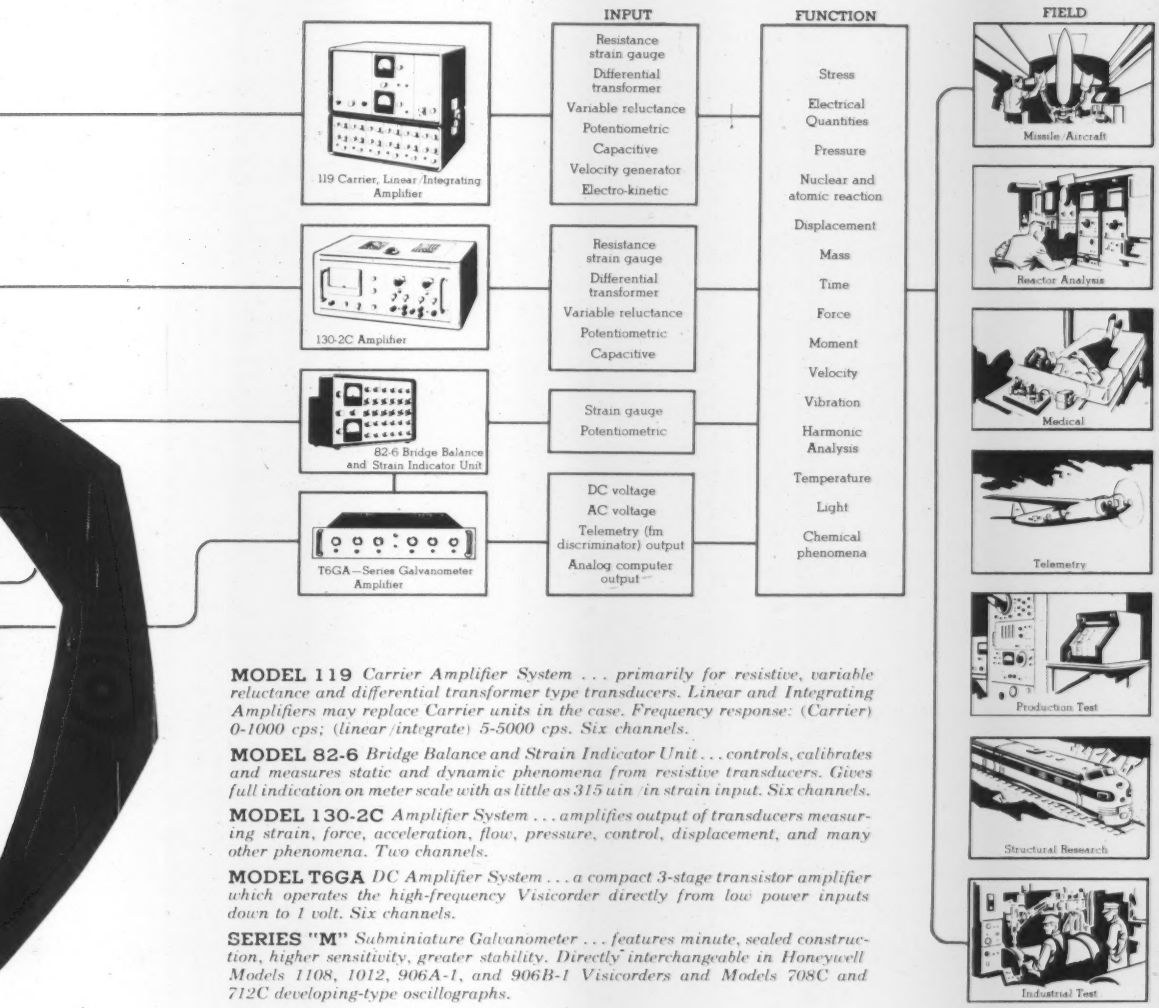


EASY PAPER LOADING . . . *Paper supply assembly swings forward, supply roll drops easily into place. No threading required.*

CONVENIENT ACCESS . . . *Covering pan cleaning of optical components, calibrating time REAR VIEW shows rear-panel input connect*



e in immediate, convenient readout of data in an



MODEL 119 *Carrier Amplifier System . . . primarily for resistive, variable reluctance and differential transformer type transducers. Linear and Integrating Amplifiers may replace Carrier units in the case. Frequency response: (Carrier) 0-1000 cps; (linear/integrate) 5-5000 cps. Six channels.*

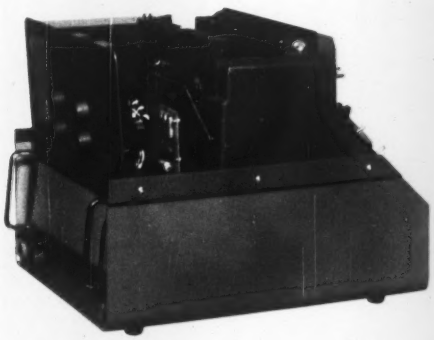
MODEL 82-6 *Bridge Balance and Strain Indicator Unit . . . controls, calibrates and measures static and dynamic phenomena from resistive transducers. Gives full indication on meter scale with as little as 315 uin/in strain input. Six channels.*

MODEL 130-2C *Amplifier System . . . amplifies output of transducers measuring strain, force, acceleration, flow, pressure, control, displacement, and many other phenomena. Two channels.*

MODEL T6GA *DC Amplifier System . . . a compact 3-stage transistor amplifier which operates the high-frequency Visicorder directly from low power inputs down to 1 volt. Six channels.*

SERIES "M" *Subminiature Galvanometer . . . features minute, sealed construction, higher sensitivity, greater stability. Directly interchangeable in Honeywell Models 1108, 1012, 906A-1, and 906B-1 Visicorders and Models 708C and 712C developing-type oscillographs.*

g panels on instrument are readily removable for easy access to lamp, g timer, and to service other assemblies. (THREE-QUARTER onnectors.)



EASY GALVANOMETER ADJUSTMENT . . . *provided through top panel. No clamping or locking is required. Galvanometer spots may be observed at recording point while adjustment is being made.*

MODEL 1108 VISICORDER

adds still more versatility to the Honeywell family of direct recording oscillographs.

Designed to the utmost standards of customer convenience, high-frequency and high sensitivity recording, and reliable, accurate performance, the Model 1108 continues the long-standing tradition of Honeywell leadership through creative engineering. Examine the diagram below for feature-by-feature evidence of this leadership.

FEATURES OF THE 1108

General Features

1. **AUTOMATIC RECORD LENGTH CONTROL** . . . *adjustable from 1 to 25 feet . . . indicator shows amount of pre-set record length remaining.*
2. **VISIBLE RECORDING POINT** . . . *galvanometer spots may be monitored through amber screen as they record.*
3. **GRID LINE INTENSITY CONTROL** . . . *manually adjustable to compensate for exposure at various record speeds. (Grid line spacing: 0.1 inch; 5th line accentuated. Custom grid spacings on special order.)*
4. **GALVANOMETER SPOT INTENSITY CONTROL** . . . *off, on, and manually adjustable to control sharpness of galvanometer traces at various record speeds and writing speeds.*
5. **RECORD NUMBERING** . . . *Four-digit resettable record-number counter photographed at start of each record. Flash-tube type; may also be used as event marker.*
6. **RECORD DRIVE CONTROL and INDICATOR** . . . *"Forward" for recording; "reverse" for closer study and analysis of data after recording has been made. Indicator signal light turns off if recording is not taking place.*
7. **RECORD SPEED INDICATOR.** *pushbuttons for 5 speeds plus 3 range pushbuttons give you 15 separate speeds. Speeds may be changed during operation. Positive clutches, no gear meshing.*
8. **TIME LINE SYSTEM** . . . *Electronic flash type, instant warmup. Three selectable intervals: 1, .1, and .01 seconds. No optical parallax. May also be operated from external signal and in multiplex.*
9. **RECORDING LAMP ON-OFF CONTROL AND INDICATOR**
10. **POWER ON-OFF CONTROL AND INDICATOR**
11. **RECORDING PAPER CAPACITY** . . . *8" x 200 feet of standard-weight paper; 350 feet of thin base paper. Take-up integral with record-drive system.*
12. **GALVANOMETERS** . . . *access through top panel. Accepts up to 24 Series M Subminiature galvos, plus 4 static reference galvos. Directly interchangeable among Honeywell Models 906A-1, 906B-1, 1012, 700C oscillographs.*
13. **PAPER KNIFE** . . . *manually operated.*

Other Features

TRACE IDENTIFICATION . . . *at 45° slope, 1/2" width, interrupting galvos in sequence on approximately 8" spacing.*

OPTICAL ARM . . . *11.8 inches (30cm) standard in all Honeywell oscillographs.*

LAMP AND CIRCUIT . . . *High-pressure mercury vapor lamp. Automatic starting.*

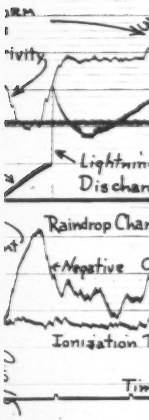
REMOTE OPERATION . . . *Control circuits provided for remote operation.*

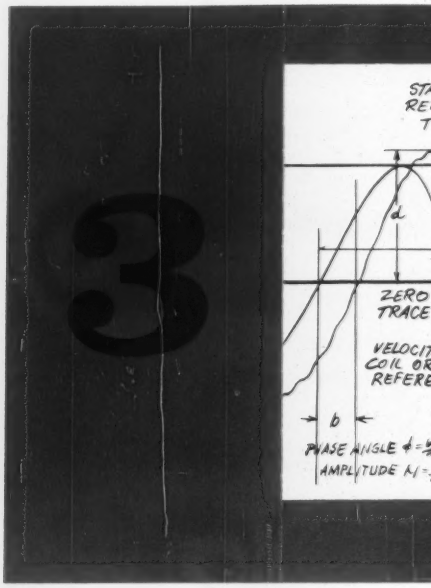
INPUT POWER . . . *105-130 volts; 60 cycle; 7 amps. 50 and 400 cycle models also available.*

MOUNTING . . . *Table and rack. Shock or vibration mounting using available accessories.*

open this page

TYPIC





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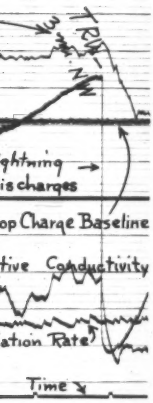
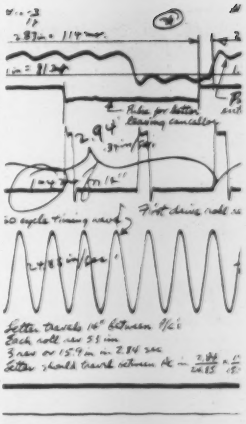
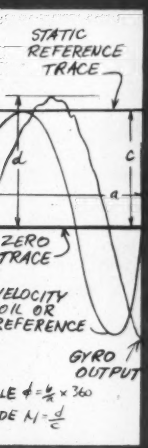
PICAL USES OF THE VISICORDER



In weather research . . .
This Visicorder record gave U.S. Weather Bureau scientists immediate readout of thunderstorm data taken at Mt. Washburn in Yellowstone National Park. As the storm system passed, the Visicorder recorded positive and negative air conductivity, rate of ionization of air, raindrop charge, corona discharge current from an insulated tree and a 4′ x 6′ grass plot, times of camera exposure photographing droplet size and electrical charge, atmospheric potential gradient, and time.

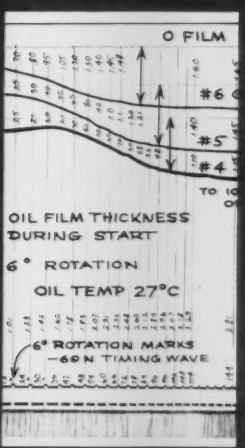
In development test . . .
This directly-recorded Visicorder record shows a canceller test of letters through a new mail-handling machine developed by Emerson Research Laboratories for the U.S. Postoffice Department. The Visicorder test took only 3 hours to solve a 3-week problem: why letters, travelling at the rate of 30,000 letters per hour, changed speed as they went through the machine. (Constant speed is necessary to register cancellation on the stamp every time.) Motor speed variations, belt slippage, and letter slippage in the drive rollers were responsible. A synchronous-drive motor, a timing belt drive, and a better grade of rubber in the drive rollers were added to solve the problem at a vast saving in engineering time.





In production . . .
This comparison test of a production gyroscope was directly recorded by a Visicorder oscillograph in the test department of the Whittaker Gyro Division of Telecomputing Corporation, Van Nuys, California. The record shows how the Visicorder compares controlled angular velocities as a reference base to simultaneously-recorded variables, and how a dual static reference trace galvanometer simultaneously establishes a base line and a calibration line on the chart.

Industrial design . . .
This Visicorder record made by design engineers at Westinghouse measured oil film thicknesses on the bearing pads of a 67,500 kilowatt water wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, oil thicknesses encountered by the leading edge, center, and trailing edge of the bearing were found to be within the limits of safety as predicted by engineering assumptions.



HER USES of the Model 1108 Visicorder . . . as a direct readout unit IN RECORDING MONITORING SYSTEMS . . . IN MISSILE AND ENGINE ANALYSIS for test stand recording analog recording OF TELEMETERED SIGNALS . . . IN CONTROL to monitor reference and gnals . . . IN NUCLEAR TEST to record temperatures, pressures, impacts, etc. . . . IN LAB-ORIES for all purpose analysis . . . IN PRODUCTION for final dynamic inspection . . . IN COM-NG for immediately-readable analog records . . . IN PILOT COMPONENT TESTS for rapid ion of prototypes . . . IN ALL TESTS which are non-repetitive in sequence, making oscilloscopes tical.

Honeywell

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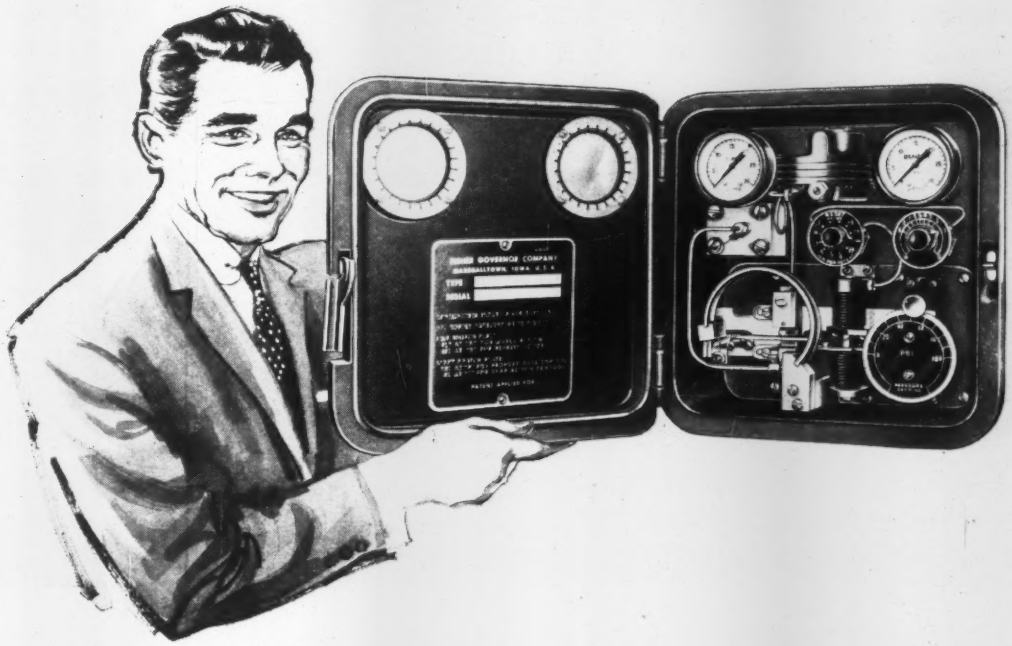
PRESSURE CONTROLLERS



- Two Position Controller
- Proportional Controller
- Proportional Controller —Remote Set
- Differential Proportional Controller
- Pressure Transmitter
- Differential Proportional Controller— Remote Set
- Proportional Reset Controller
- Differential Proportional Reset

This "Jack of ALL Trades" is surprisingly low in cost

The partial list of applications at left tells you why the Wizard II is so aptly named. Probably no other controller in the Fisher line is as versatile. Available in brass, steel or stainless steel Bourdon tubes for ranges from 25 to 10,000 psi. Brass or stainless steel bellows available for low pressure service from 30″ Hg Vacuum to 30 psi.

Fisher has carefully designed each component of the new Wizard to satisfy the most rigid process control requirements. A completely descriptive and illustrated booklet on the Wizard II is yours for the asking. Write for Bulletin D 4150 A.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

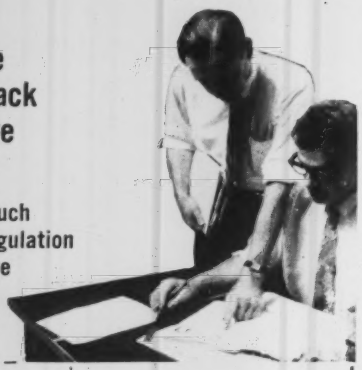
SINCE 1880

CIRCLE 32 ON READER-SERVICE CARD

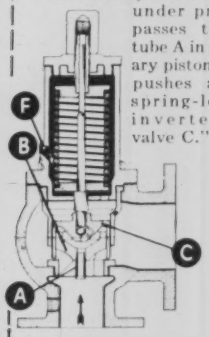
← CIRCLE 31 ON READER-SERVICE CARD

"How does the Klipfel #135 back pressure valve work?"

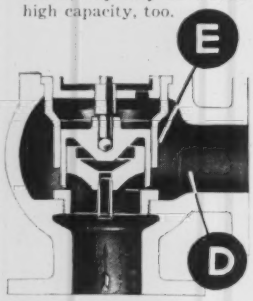
How can it give such close pressure regulation (4% over the entire capacity range)? Here's the story:



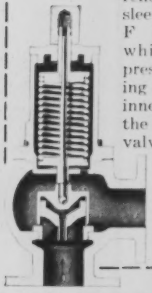
"Controlling inlet pressure and flow in a pipe line is all any back pressure valve does. How *well* it does this is, however, a different story. In this Klipfel Valve liquid under pressure passes through tube A in stationary piston B, and pushes against spring-loaded, inverted-cup valve C."



"When liquid pressure exceeds spring pressure, valve lifts open, letting liquid flow into outlet chamber D. This shows how Klipfel No. 135 Valves give such close regulation; why they have such high capacity, too.



"This is the same back pressure valve, modified to act as a relief valve. As you might guess, relief valves prevent excess pipe line pressures by relieving to the atmosphere. The only difference between the two valves is that the relief valve has no sleeve E and vent F (above)—which prevent pressure from acting downward on inner valve C in the back pressure valve."



"MOST IMPORTANT FEATURE in any back pressure or relief valve (aside from dependability) is smooth, chatter-free opening and closing. Also, relief valves should close tightly, but this isn't so important in back pressure valves."

• For the complete story of back pressure and relief valves, without cost or obligation, write for Bulletin 454.

HAMILTON • OHIO **Klipfel** VALVES INC.

Automatic Temperature and Pressure-Regulating Valves Since 1902

Float Valves • Temperature Regulators • Back Pressure Valves • Reducing Valves

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

CIRCLE 33 ON READER-SERVICE CARD

stock report

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1959 THRU OCTOBER 14, 1959

	High	Low	Price As Of 10/14/59
ACF Industries	57	47 5/8	51
Aeroquip Corp.	34 3/4	23 5/8	28 1/2
Allis Chalmers	38 3/4	26 7/8	35
American Chain & Cable	61 3/4	47 3/4	52 1/2 - 53 1/2(1)
American Machine & Foundry	100	53 1/2	92
American Machine & Metals	59 3/4	41	45 3/4
American Optical	53 1/2	38 3/8	49
American Tel. & Tel.	89	75 1/8	78 5/8
Ampex Corp.	88 1/4	61 1/4	84
Bausch & Lomb Optical	40 1/2	27	34
Beckman Instruments	74 3/4	56 1/4	56 1/4
Bell & Howell	74 3/8	53 1/4	66
Bendix Aviation	89	61	64
Boeing Airplane	46 1/2	29 7/8	32 3/8
Bullard	24 7/8	16	16 5/8 - 17(1)
Bulova Watch	20 5/8	13 3/8	14 3/4
Burroughs	45 3/4	29 1/8	30 1/4
Carborundum	56 3/4	37 3/8	46 1/2
Cincinnati Milling Machine	47 5/8	36	38 1/2
Clevite	40 3/8	24 3/4	33
Columbia Broadcasting System	48 3/4	35	43
Consolidated Electrodynamics	45 1/2	30 3/4	34
Consolidated Electronics	53	33 1/2	46 3/8
Cornell Dubilier	30 1/2	18	19 1/8
Corning Glass	150 1/2	69 3/4	131 1/4
Curtiss Wright	39 1/2	27 1/8	32
Cutler-Hammer	94 1/4	59 1/2	86
Daystrom	49 3/4	34	37 3/4
Douglas Aircraft	59 3/4	42 1/2	43 3/4
Eastman Kodak	97 3/8	75	85 1/4
Eaton Mfg.	42 (New)	29 1/4	41 1/4
Electric Auto-Lite	55 1/2	36 1/4	50 1/2
Elgin Watch	14	9 3/4	10 5/8
Emerson Electric	69 7/8	48 1/8	56
Food Machinery & Chemical	55 3/8	40	51
Gamewell	39 1/4	27	30 1/8
Garrett	50 7/8	35	42
General Controls	39 1/4	24	29 3/4
General Dynamics	66 1/2	44	46 1/2
General Electric	84 3/4	74	76 1/2
General Instrument	38 3/8	18 1/2	25 5/8
General Mills	57 5/8	36 1/2	52 7/8
General Precision Equipment	45 1/2	31 1/2	42 3/8
General Railway Signal	59 1/4	40 1/4	51 1/2
General Tel. & Elec.	79	56	64 7/8
General Time	104 1/2	75	75 1/4
General Tire & Rubber	83	44 1/8	70 1/8
International Bus. Machines	486	389 1/2	467 1/4
International Tel. & Tel.	45 1/2	26	35 7/8
I-T-E Circuit Breaker	50 1/2	36 5/8	41 1/2
Litton Industries	133 7/8	72 5/8	117 1/2
Lockheed Aircraft	59 5/8	24 5/8	28 7/8
Magnavox	70 3/4	48 1/4	61 5/8
Mallory	48 3/4	36 1/4	38 5/8
Minneapolis-Honeywell	150	111 1/2	117
Minnesota Mining & Mfg.	151 1/2	111 1/2	143
Motorola	130	57 1/2	107 1/4
National Acme	63 1/2	50 1/8	54 1/4
National Cash Register	80	55 1/8	62 3/8
Neptune Meter	39 5/8	29 1/4	30
North American Aviation	52 5/8	30 1/4	37 1/4
Northrop Aircraft	44 3/4	24 5/8	29 3/4
Otis Elevator	83	61 1/2	72
Philco Corp.	36 3/4	21	26 1/8
Radio Corp. of America	71	43 1/8	58 7/8
Raytheon Mfg.	73 7/8	43 1/2	52 3/8
Reliance Electric	63 1/2	42 5/8	59 1/2
Rheem Mfg.	25 3/4	17 3/4	20
Robertshaw Fulton	53 7/8	31 5/8	45 1/4
Royal McBee	24 3/8	16	17 3/8
Sangamo Electric	51 1/2	35	37 1/2 - 38 1/2(1)
Siegler Corp.	45 1/8	23 1/8	30 1/4
Sperry Rand	28 1/4	21 1/4	22
Square D	37 1/4	26 7/8	31 7/8
Standard Coil Products	23 3/4	13 3/4	15 3/8
Starrett (L.S.)	23 7/8	20	20 3/4
Stewart-Warner	62	42 1/2	53 1/4
Telautograph	13 3/8	9	10 5/8
Texas Instruments	159 1/2	61 1/4	143 1/4
Thompson-Ramo-Wooldridge	70 1/4	52	55 3/8
Tung-Sol Electric	54 1/4	34 1/8	38 1/2
Underwood Corp.	30 7/8	19 1/4	21
Union Carbide Corp.	150 1/2	120 1/2	139 3/4
United Shoe Machinery	58 3/8	45 5/8	54
Varian Associates	33 1/2	26 3/4	31 3/8
Wallace & Tiernan	52 7/8	36 1/4	42 1/2
Western Union	43 7/8	29 3/4	30 3/4
Westinghouse Air Brake	38 1/2	27 1/2	30 5/8
Westinghouse Electric	98 3/8	70 1/2	93 3/4
Worthington Corp.	84 1/2	67 1/2	68 3/4

(1) Not traded — Bid and Asked.

These prices and price ranges are given as printed in the Wall Street Journal.

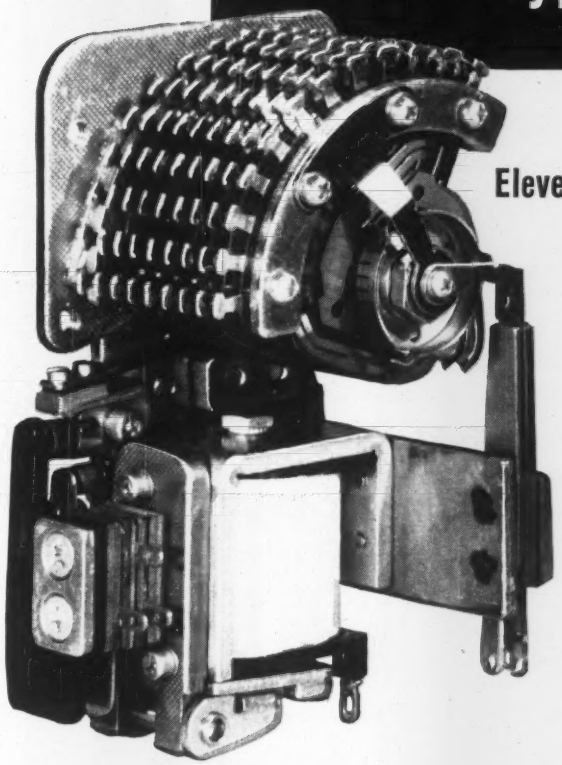
AMERICAN STOCK EXCHANGE

PRICE RANGE 1959 THRU OCTOBER 14, 1959

	High	Low	Price As Of 10/14/59
American Meter	47 1/4	38	43 1/4
Aro Equipment	29 3/4	20 3/4	22 1/4
Barry Controls "B"	26	13 3/4	18 1/2 - 19(1)
Belock Instruments	22 7/8	10 3/8	16 1/2

Continued on page 1642

CLARE ANNOUNCES THE Type 211 Stepping Switch



Eleven-point stepping switch has 12-level capacity, 100,000,000-step* life

Many new, improved features give this Clare Type 211 springdriven stepping switch longer service life, greater capacity and a freedom from maintenance hitherto unknown in an 11-point switch. Rugged, compactly built, the 211 is available with a variety of enclosures and mounting assemblies to meet a wide range of design applications.

LONGER LIFE EXPECTANCY—This new switch has a life expectancy of from 100 million steps at twelve levels to 300 million steps at three levels with proper relubrication and readjustment.

GREATER STEP CAPACITY—Up to twelve 11-point levels or four 33-point levels enable it to handle complex switching, counting, totalizing, selecting, and sequence control operations.

SIMPLIFIED MAINTENANCE—Fewer moving parts, due to the elimination of pawl bearings, and a more rigid armature arm simplify maintenance and increase service life.

TYPE 211 SWITCH—ELECTRICAL DATA

OPERATING SPEEDS—Self-interrupt speed: 60 SPS at 25°C on nominal voltage. Remote impulse speed: 30 SPS at 25°C on nominal voltage with 66% make impulse.

OPERATE & RELEASE TIME—Operate time: 20 ms at 25°C on nominal voltage. Release time: 10 ms at 25°C on nominal voltage.

OPERATE & RELEASE VOLTAGE—Maximum pull-in at 25°C is 66% of nominal voltage. Minimum dropout at 25°C is 5% of nominal voltage.

BREAKDOWN TEST—1000 v, rms, 60 cps, is standard.

COILS—Coil resistances for typical voltages are shown below:

Voltage	1-8 Levels	9-12 Levels
Vdc	Ohms	Ohms
6	1.5	1.5
12	6	6
24	24	20
48	100	70
60	150	100
110	600	400

TYPE 211 SWITCH—MECHANICAL DATA

OVERALL DIMENSIONS—Length (maximum)—4-5/16 in. Height (1C interrupter, 1C O.N.S.)—2¾ in. Width—from 1-5/16 in. for 3 levels to 2-13/16 in. for 12 levels.

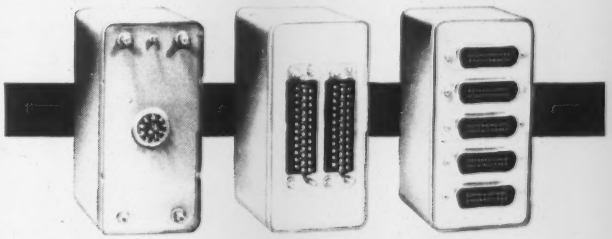
NET WEIGHT—From one pound for 3 levels to 1½ pounds for 12 levels.

BANK CONTACT—Standard is phosphor bronze. Also available are coin silver or gold plated phosphor bronze.

MAXIMUM BANK LEVELS & PILEUPS

Type of operation (points)	11	33
Bank levels maximum (electrical)	12	4
Interrupter springs	6	6
Off-normal springs	6	6
Number of ratchet teeth	33	33

WIPERS—Standard wipers are non-bridging phosphor bronze with coin silver and gold plated phosphor bronze available in either non-bridging or bridging models.



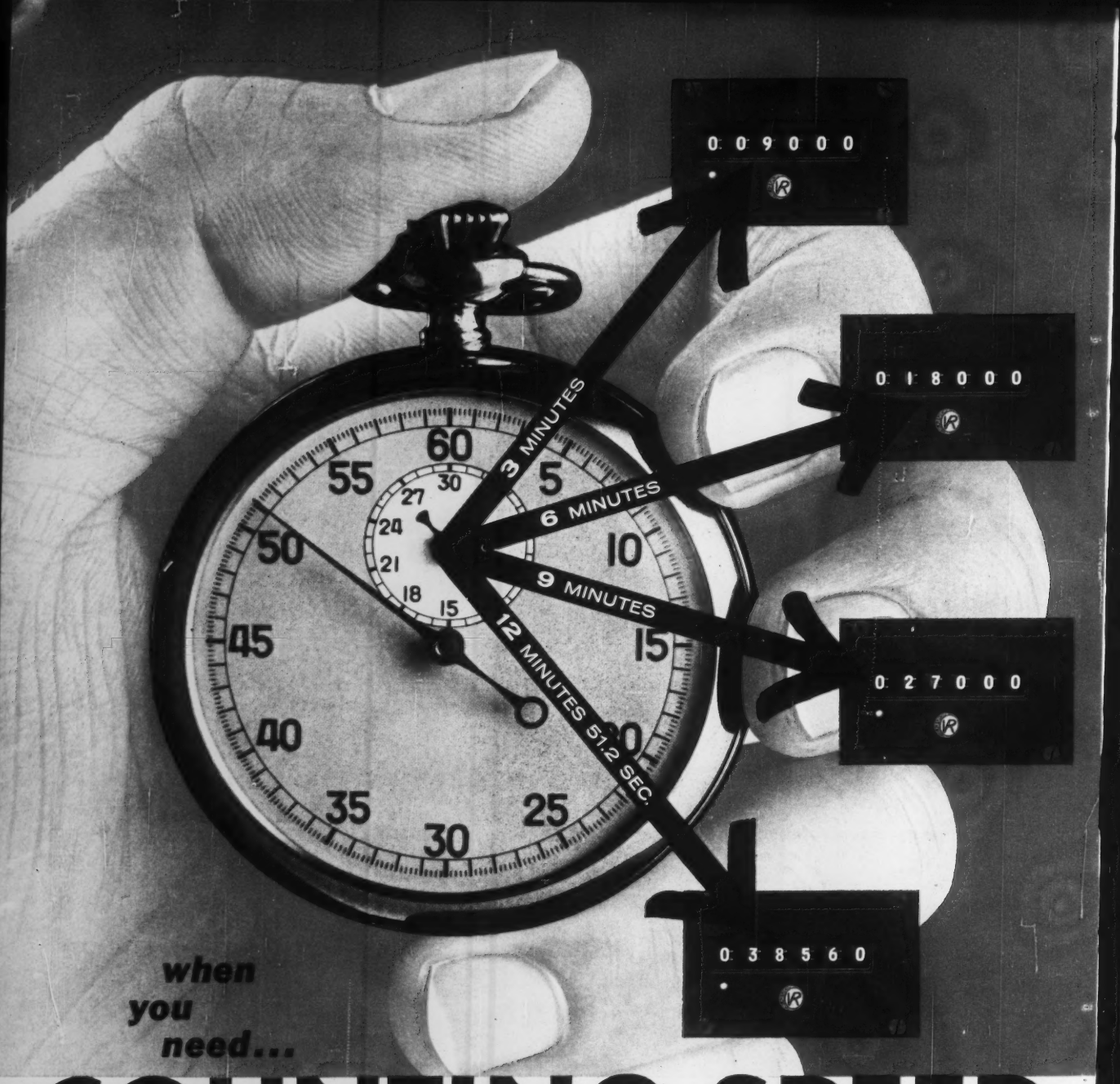
VARIETY OF ENCLOSURES—Hermetically sealed enclosures, filled with nitrogen or oil, are available with hook-type solder terminals. Dust cover enclosures are available with miniature or standard Amphenol Blue Ribbon connectors.

Write for bulletin CPC-3 to C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the Industrial Field

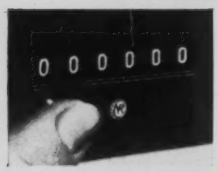
CIRCLE 34 ON READER-SERVICE CARD



when you need...

COUNTING SPEED

Specify VEEDER-ROOT No. 1591 Quick Reset, High Speed Magnetic Counter



The No. 1591 resets to zero with the flick of a finger with manual reset, or in one second with electrical reset.

The No. 1591 is designed for accurate, dependable remote indication of machine operation, or for counting articles at high speed. Speed is 3000 counts per minute, 4 or 6 figures, manual or electrical reset, and made for panel mounting. Maximum panel area required is: 1.7″ x 2.1″ for four figures and 1.7″ x 2.8″ for six figures. The 1591 is *available from stock.*

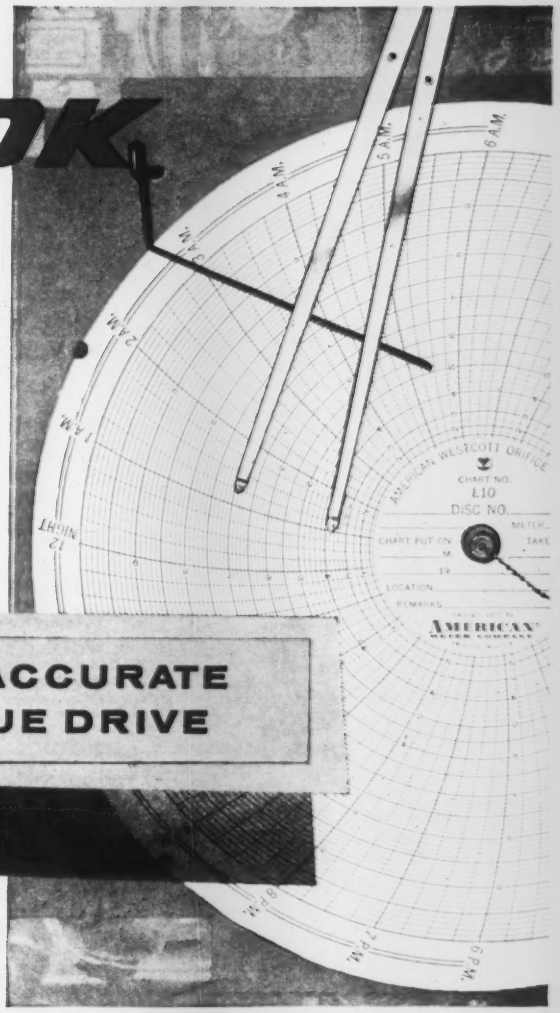
Send for Veeder-Root Technical Information. Complete catalog data will be sent to you at once and application assistance is available from a Veeder-Root Counting Engineer if desired. Write or call today.

Veeder-Root Inc.
HARTFORD 2, CONNECTICUT
"The Name that Counts"

Hartford, Conn. • Greenville, S. C.
Altoona, Pa. • Chicago • New York
Los Angeles • San Francisco • Seattle
St. Louis • Montreal. *Offices and Agents in other principal cities*

CIRCLE 35 ON READER-SERVICE CARD

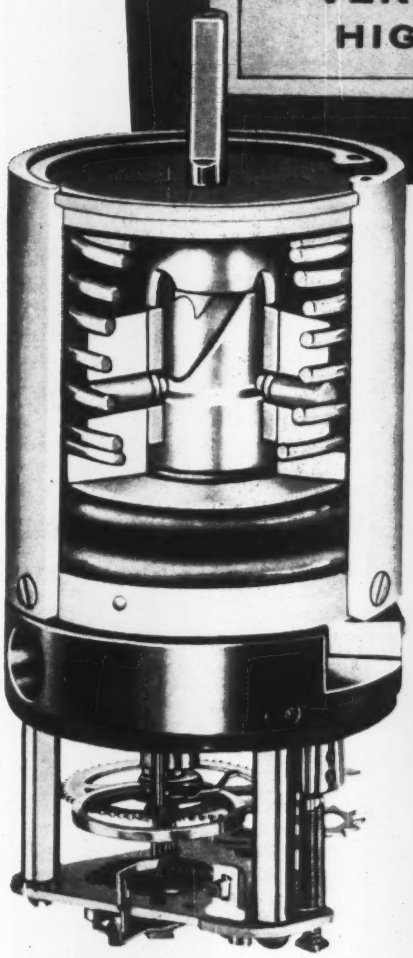
AMERICAN®
GASCLOK
POWER DRIVE



Check these features--

- Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations.
- Constant high power...more than 20 times the torque delivered by conventional spring-wound mechanisms.
- Timing accuracy continuous...no heavy "mainspring" to weaken or run down...unaffected by a ± 20% variation in supply pressure.
- Self-starting...no winding or priming of power unit.

VERSATILE • ACCURATE
HIGH TORQUE DRIVE



- Flexibility...ideal as original or replacement equipment for strip chart and conventional circular chart instruments.
- Built-in durability...timing mechanism internally sealed to prevent corrosion...large area internal ports prevent clogging.
- Rugged dependability...all power unit parts exposed to gas are aluminum or stainless steel...inherently explosion proof.
- Economical...normal air or gas consumption 5 cfh...operating pressure 5 psi...rotation 2 rpm.

Then ask
your American representative how the versatile ***GASCLOK*** can provide new metering accuracies and economies for you.

AMERICAN METER CO

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood • IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves.

CIRCLE 36 ON READER-SERVICE CARD

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ball & disc
integrators

$90.00
MODEL 219 with
standard control rod

Highest accuracy and reproducibility at lowest cost. Smooth, reliable operation for precise integration and control applications such as flow totalization, speed control, strain analysis or continuous weighing.

Write for complete engineering and applications data.

ACCURACY: ±0.1%
REPRODUCIBILITY: ±0.01%
OUTPUT TORQUE: 3 oz.-in. (higher outputs at reduced accuracy)
INPUT TORQUE: 2 oz.-in. (no output load)
CONTROL ROD: Vernier, rack, screw, or plain. Special rods designed to specification
CONTROL ROD FORCE: 3 oz. static 1 oz. dynamic
INPUT SPEED: 0-750 rpm
OUTPUT SPEED: Reversible up to more than twice the input

REFLECTONE

REFLECTONE ELECTRONICS, INC. • STAMFORD, CONN.
CIRCLE 37 ON READER-SERVICE CARD

American Stock Exchange

Continued from page 1638

Genrus	9	5 7/8	7
Breeze Corp.	9 3/8	6 1/4	6 5/8
Clark Controller	30 3/8	19 5/8	22 1/2
Clarostat Mfg.	10 1/4	4	7 1/2
Clary Corp.	10 7/8	5 3/4	7 1/8
DuMont Laboratories	9 7/8	6	8 1/8
Dynamics Corp. of America	12 3/4	4 5/8	8 1/8
El-Tronics	2 1/4	1	1 1/4
Electronics Corp. of America	16 7/8	7 1/2	9 1/2
Fairchild Camera & Instrument	205	90 3/4	173 1/4
General Transistor	45 3/8	29	35
Globe-Union	27 3/4	20 1/4	23 1/4
Hazeltine Corp.	33	23 1/2	25 1/8
International Resistance	22 3/4	7	15 1/4
Lear Inc.	19 1/4	9 1/8	16 3/4
National Research	39 1/2	15 3/8	22 1/2
New Haven Clock	5 3/8	1 1/2	2 1/2
Nuclear Corp. of America	4 1/4	1 3/4	2
Philips Electronics, Inc.	50 1/4	23 1/2	36 3/8
Pneumatic Scale	67	32	41 1/2 - 43(1)
Servo Corp. of America	43 1/2	14 5/8	22 1/2
Servomechanisms	18 1/4	9	10 7/8
Statham Instruments Inc.	43	23	27
Victoreen Instrument Co.	19 7/8	6 7/8	12 5/8
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 1/4

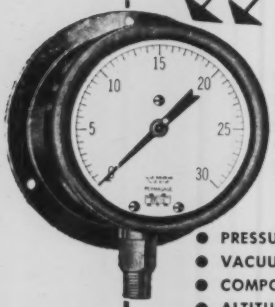
(1) Not traded — Bid and Asked.

These prices and price ranges are given as printed in the Wall Street Journal.

OVER THE COUNTER	Quotation as of 10/14/59	
	Bid	Asked
Aerovox Corp.	9 1/2	10 1/4
Aircraft Radio Corp.	53	--
Argus Corp.	34 1/4	35 1/4
Black Sivalls & Bryson Inc.	19 1/2	21 1/2
Eitel McCullough	23 1/4	24 1/4
Electro Instruments	39	41 1/2
Electronics Associates	31	34
Erie Resistor Corp.	7 1/4	7 7/8
Fisher Governor Co.	16 3/4	17 7/8
Foxboro Company	68	72
Giannini Controls	27 1/2	30
Hagen Chemicals & Controls	32 1/4	33 1/2
Industro Transistor	7	7 1/2
Liquidometer Corp.	9 1/4	10 1/2
W. L. Maxson	10 1/8	11
Penn Controls	21 1/4	22 1/4
Speer Carbon, Inc.	19	21
Sprague Electric	54	56 1/2
Taylor Instruments	34 1/2	35 1/2
Telecomputing Corp.	8 7/8	9 1/2
Topp Industries	10 1/4	11 1/4
Vitro Corp. of America	11	13 1/4

MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS



Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

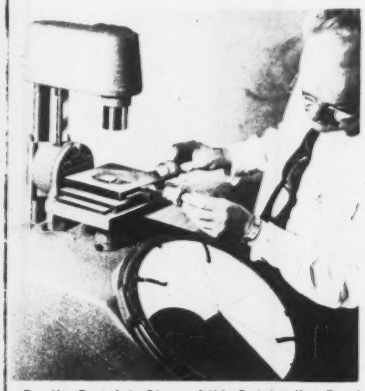
- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

CIRCLE 38 ON READER-SERVICE CARD

Be Sure... Be Safe...
Inspect by Projection!



SCHERR MICRO PROJECTOR
Self-Contained Model
with the
VERTICAL DESIGN

Get the full story of this outstanding tool . . .

For the Complete Story of this Outstanding Precision Tool — Contact any of our 3 "Coast to Coast" Locations or your nearest Local Distributor.

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West Coast Office: SCHERR-TUMICO CO.
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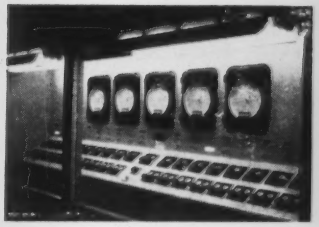
CIRCLE 39 ON READER-SERVICE CARD

HAGAN NEWSLETTER

Behind the Panel



ANOTHER STEEL INDUSTRY FIRST FOR HAGAN

A large eastern mill has ordered what is believed to be the industry's first solid state combustion control system. Hagan PowrMag (magnetic amplifier) systems will be installed on a two-zone slab heating furnace, and will include zone temperature, zone fuel-air ratio, furnace pressure, recuperator temperature balance, and air pressure controls. Recording instruments (Hagan PowrLog) and panels will also be Hagan. Using PowrLog electronic recorders and PowrMag controllers, the system for each zone provides parallel operation of the combustion air damper and fuel oil control valve from the zone temperature controller. Fuel and air are measured and a fuel-air ratio correction is applied to the combustion air damper. The combustion air flow measurement is automatically compensated for temperature variations. Gas firing is contemplated for the future. (Item L-1)

GAS CONTRACT PENALTIES AVOIDED WITH RING BALANCE METERING

The increasing use of gas in the steel industry has brought about the necessity for central gas dispatching stations. By accurate control of gas usage, large users can avoid the penalties incurred when gas contracts are exceeded, and at the same time, make maximum use of available coke oven gas. Hagan Ring Balance meters have been chosen for this critical application by a large mid-western steel mill for a number of reasons, the most important being the inherent accuracy of the Ring Balance principle. This basic accuracy is reinforced by the ability of the Ring Balance to compensate precisely for fluctuations in pressure and temperature, and the ease with which it can be calibrated. Add rugged construction, accurate electrical remote transmission and the ease with which range can be changed on a 7 to 1 basis, and the Ring Balance becomes the meter of choice for such applications. (Item L-2)

THESE SYSTEMS HAD TO BE EASY TO INSTALL

Easy to install—easy to calibrate—are commonly used phrases in the control business. But one Central American plant is willing to testify that this is strictly true—as far as Hagan systems are concerned. Combustion control, drum level control, meters and control panels were purchased from Hagan for a new 110,000 lb/hr boiler for a Central American steam electric station. Using Hagan instruction books and drawings, the entire system was installed, calibrated and put on the line without a single hitch, and a Hagan engineer has never been at the plant. All the systems have been functioning "beyond expectations" and maintenance has been minimum. (Item L-3)

HOW TO MEASURE A SMELL

To further decrease the risks of handling natural gas, an odorant is frequently added when the gas is transferred from underground storage areas back into the distribution system. The amount of odorant added is extremely critical, since too much makes the smell extremely objectionable, while too little makes the detection of gas leaks difficult. For this service, a pressure compensated Ring Balance meter, together with a Hagan ratio relay, controls a proportioning chemical feed pump. Installations of this accurate team are in service at a major gas supplier in the mid-west. Odorization of the gas is extremely accurate, and the installations have more than met the stringent specifications. (Item L-4)

HAGAN CONTROLS DO "SUBMARINE" SERVICE ON SURFACE VESSEL

One of our largest surface ships is equipped with Hagan controls, including combustion, feed water and boiler feed pump systems. On a recent cruise, a defective main condenser valve allowed a main machinery space containing the Hagan combustion and feed pump controls to be flooded. The control systems were under water for a total of 36 hours. Crew members cleaned up the equipment, and when the carrier docked, Hagan service representatives were requested to check out the control systems. The controls were found to be in first class condition, needing only two minor needle valve adjustments. Hagan marine systems are not only extremely accurate, providing the most economical operation, but they are built to "take it." (Item L-5)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 710, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy
If you would like more information on any of the above items, check the appropriate box below.

☐ Item L-1 ☐ Item L-2 ☐ Item L-3 ☐ Item L-4 ☐ Item L-5

FOR MORE INFORMATION ON L-1 CIRCLE 40; L-2 CIRCLE 42; L-3 CIRCLE 43; L-4 CIRCLE 44; L-5 CIRCLE 45 ON READER-SERVICE CARD

for library, gifts, training course

Electronic Circuitry for Instruments and Equipment

by M. H. Aronson. "Comprehensive source book on instrument circuitry," this complete home-study text includes 458 multiple-choice questions (and answers); 215 illustrations, 10 tables, comprehensive index. Paperbound, 324 pages, 1957 (revised edition). **$2.00**

Printed Circuitry

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperboard, illustrated, 192 pages, 1957. **$2.00**

Maintenance and Servicing of Electrical Instruments

by James Spencer. Useful to all instrument users, service men, switchboard attendants, testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound, 274 illustrations, 280 pages, 1951 (third edition). **$2.00**

100 Electronic Circuits

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957. **$2.00**

Strain Gage Instrumentation

edited by Aronson and Nelson. " . . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated, indexed by company, author, and subject, 1958. **$2.00**

Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availability (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, illustrated, 1954. **$2.00**

Process Control

by A. J. Young. A "must" for all who have to do with the automatic control of industrial processes, this book combines for the first time the practical "how" and the theoretical "why". Paperbound, 134 pages, 1957 (second printing). **$2.00**

Operation and Care of Circular-Scale Instruments

by James Spencer. Includes "trouble" charts for d-c, and for a-c instruments; covers d-c instruments, a-c ammeters and voltmeters, wattmeters, frequency meters, power factor meters and synchroscopes. Clothbound, 90 pages, 1949. **$2.00**

Regulators and Relief Valves

by Chester S. Beard and Fred D. Martcn. Covers regulators for pressure, vacuum, flow, temperature, level, gas systems, and pump discharge. Also safety, relief, and safety-relief valves; and automatic emergency valves, including shut-off valves for oil and gas transmission lines. Paper, 204 pages, illustrated, 1959. **$2.00**

Introduction to Process Control System Design

by A. J. Young. ". . . provides a simple introduction to the study of process control systems and the factors which influence their design." Aimed particularly at those who (not necessarily instrument specialists) are concerned with automatic control as a tool or technique for increasing plant efficiency. Cloth, illustrated, 398 pages, 1955. **$6.00**

Mechanical Measurements by Electrical Methods

by H. C. Roberts . . . describes gaging methods based on variations of capacitance, inductance, resistance, as well as photoelectric piezoelectric, thermoelectric, acoustic, and other methods . . . covers principles of bridge and potentiometer circuits, plus required and available equipment. Second edition, cloth, 368 pages, 1951. **$2.00**

A Romance in Research

The Life of C. F. Burgess by A. McQueen with Technical Appendix by O. W. Storey. Glimpses of the early days of radio, talkies, television. Cloth, 430 pages, 1951. **$2.00**

The Automatic Factory

by June, et al . . . a fresh viewpoint on what "manless factories" can be . . . free from the generalities, and misconceptions so prevalent on this subject. Cloth, 88 pages, 1955. **$1.50**

INSTRUMENTS PUBLISHING CO.

845 Ridge Ave., Pittsburgh 12, Pa.

panhandle pete

WESCO! plans for the Future

As all you readers (?) know, WESCO! uses only the latest techniques in all fields to make sure that it keeps ahead of all developments. One way we do this is by careful analysis of all TRENDS. Just what our industry would do without the constant trending of the many trade journals in our field is hard to imagine. So WESCO! management asked Waldo Klapsaddle, our genial sales manager, to assemble the most important trends from the various magazines in the field, so we can plan our future with confidence. As many others might like to plan their future with confidence, WESCO! is happy to let others see these important trend items, carefully culled (1642 man-hours of work) from the important publications in our field:

INSTRUMENT INDUSTRY REPORT—Sum total of losses in various systems divisions of instrument manufacturers will exceed $1 billion for first time in 1960; 98.4% of all instrument manufacturers will enter systems field; 99.2% of all aircraft and missile firms will enter instrument industry.

INSTRUMENT EDUCATION REPORT—92% of all universities will report success in eliminating measurement and other hardware courses. Foundation For Instrument Education will announce ten more education projects.

INSTRUMENT TECHNICIAN REPORT—1000-manhour 500-question report on "what an instrument technician is" will discover that (1) instrument technician assists engineer, (2) works in industry, (3) needs to know measurement and control.

TECHNICAL SOCIETY REPORT—Instrument Societies will report 146.2% increase in income from exhibits and advertising space in

society journals. Members dues will be raised, and all members will be offered opportunity of buying national proceedings papers (formerly available for free).

TRADE JOURNAL REPORT—Three new control magazines will appear in 1960. All existing control journals will report that they are "in the black" for the first time, and will cut paper and editorial quality.

TREND REPORT—Trend reports will increase 746.4%; 98.4% of all editors will interview 76.2% of all instrument authorities. All interviews will be published in 1742 pages in trade journals. They will discover (1) nation rests on a firm foundation of instrumentation. (2) future for instrumentation is very bright. (3) automation means expanding economy.

LABOR REPORT—96.6% of unions will strike, demanding protection against introduction of automation.

MARKET REPORT—Experience has shown that the future market will be very different from the past markets; future customers will emerge from unpredictable areas. Efforts to predict these areas will be stepped up 246.30%.

RUSSIAN INSTRUMENT REPORT—7.8% of leading instrument authorities and 98.4% of all editors in instrument fields will tour Russia. Concensus of reports will reveal that (1) Russian system is hopelessly inefficient and behind the times and (2) we will be hard pressed to keep up with them.

CHINESE INSTRUMENT REPORT—Serious subversive threat will be emergence of Chinese publications posing as American Systems Engineering Journals. Much subscription and advertising money will be wasted before readers and advertising agencies realize that Chinese symbols are not operational mathematics.

MEDICAL INSTRUMENT REPORT—By 1962 more doctors will be working on research on how to live in outer space than on research on how to live on earth, which may be impossible to live on by 1970. This proves far-sightedness of national leaders.

Panhandle Pete

BENDIX-PACIFIC TESTS TELEMETERING PACKAGES 10 TIMES FASTER

The TEC "add-a-unit" System Analyzer specified by Bendix-Pacific will test continuity, hi-pot, leakage, voltage rating and impedance – automatically and in trouble shooting sequence. Faults are printed out for fast corrective maintenance.

The TEC System Analyzer replaces manual testing for all tests – not just continuity – meaning complete and reliable testing in a fraction of the time.

Automation data now available for your file explains the many applications of complete automatic testing. For your copy, turn to the inquiry card and circle the number below.

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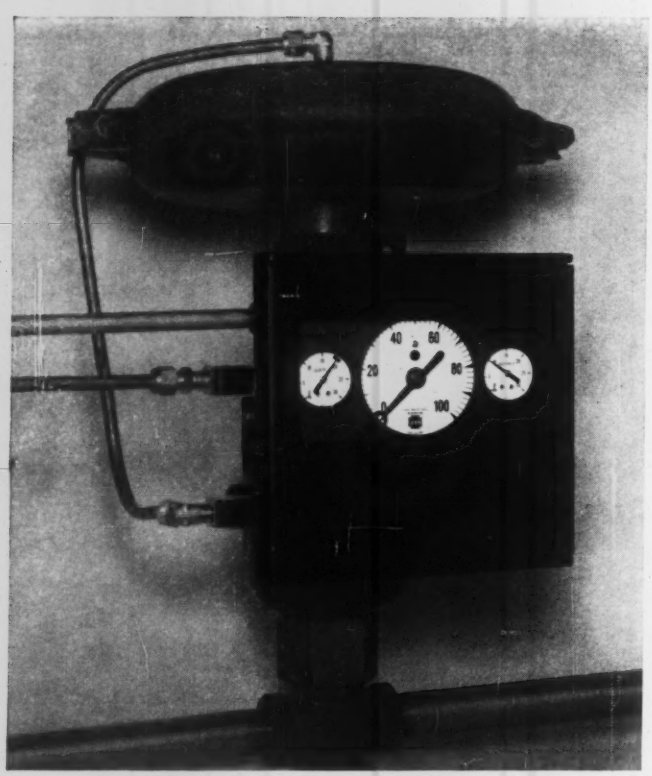
CIRCLE 47 ON READER-SERVICE CARD

New from United States Gauge...

11

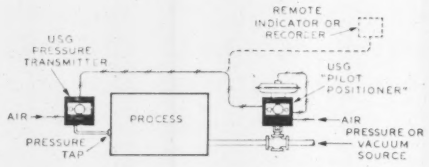


Wide controller model range. The USG Pilot-Positioner is available with most controller models in the USG Pilot line. These include pressure measurement from 30 in. Hg vacuum to 10,000 psi (applicable to liquid level as well), and temperature measurement from —350F to 1000F. Also, proportional band, adjustable for 0 to 75%, or adjustable differential gap (for fast-stroking valve). Unit measures a compact 8½ in. square.

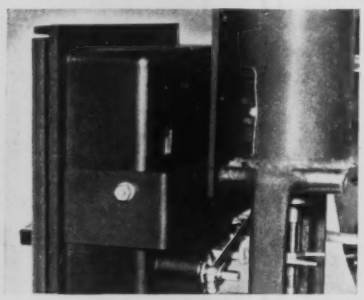
NEW! USG CONTROLLER AND VALVE POSITIONER COMBINED!

. . . in low-cost, valve-mounted
U.S. Gauge Pilot-Positioner

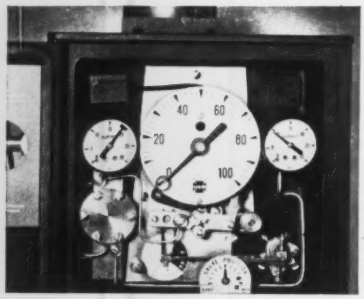
First practical combination of an indicating pneumatic controller and a valve positioner. One compact unit for temperature or pressure control and quick, accurate valve positioning. Check details here. Then send for Bulletin FO29 today!



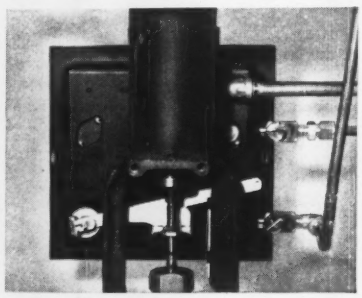
The unit can have its measuring element directly connected to the process. Or, as shown in diagram, it can be a pneumatic receiver for use with all makes of pneumatic transmitters. This permits additional indicating or recording at a remote panel board, as well as indication of the variable at the valve.



Eliminates second unit! Valve-mounted close to the process, the USG Pilot-Positioner minimizes transmission lags, provides higher precision and speed in valve action. Need for separate valve positioner is eliminated, cutting initial cost of two controls and saving on installation and maintenance. Unit fits any standard diaphragm motor valve.



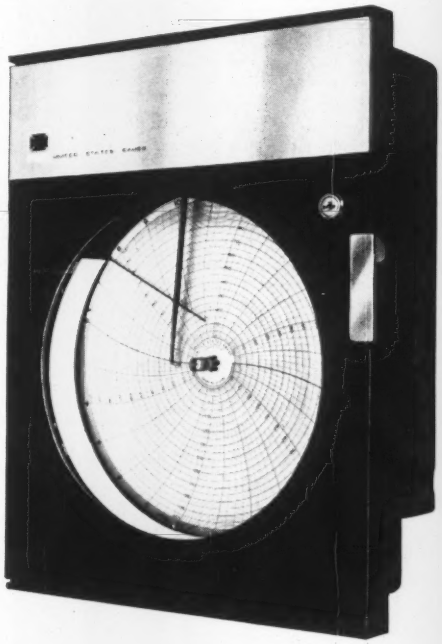
New non-bleed relay. Faster, more accurate and positive positioning action is assured with a new USG-designed, high capacity non-bleed relay. A control by-pass panel with manual-automatic-service positions is offered as an option, mounting underneath the instrument case. Another option permits remote pneumatic set point adjustment.



Mechanical feedback; one air supply. The new Pilot-Positioner employs mechanical feedback through a lever system. Controller's pneumatic components are used to amplify air pressure. Only one air supply required and pressure can be as high as 65 psi. Adjustable for valve stem travels from ⅜ in. to 4 in. Valves can be air-to-open or air-to-close.

CIRCLE 48 ON READER-SERVICE CARD

additions to the USG line!



NEW! MODERNIZED RECORDER HAS UNIVERSAL CASE FOR ALL MOUNTINGS AND CONNECTIONS

Also features largest chart opening in the industry

Now, the time-proved, field-proved United States Gauge 12-inch pressure and temperature recorder with completely new, trim, practical exterior design . . . including many important features found only on higher priced instruments. Now, outside and in . . . the USG Recorder offers still more quality, performance and advantages at a money-saving price. Write for Bulletin 3025.

Recessed back. Connections can enter case vertically or horizontally without special mounting.

Largest chart opening in the industry. 11¼-in. diameter for better visibility of chart. Shatterproof glass or blind door optional.

Removable door. New hinge pins permit easy removal of door for access to instrument.

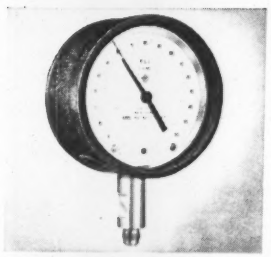
Light weight. Cast aluminum case. Steel back plate provides rigid reference surface for components, prevents recording errors due to stress on case.

Modern design. Enhances modern equipment. Stainless steel escutcheon can be embossed with equipment manufacturer's name.

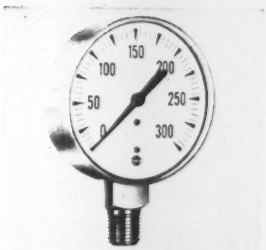
Fluorescent lighting optional. Ends over-heating of case. Improved door skirt increases light on chart.

Dust ledge. Top and bottom. Protects door from dust, moisture.

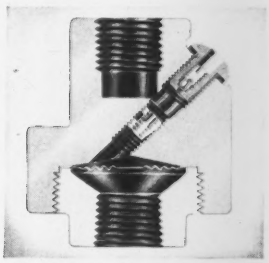
Ball pivoted pen movements. Exclusive. For 1, 2, 3 or 4 pens.



New Temperature - Compensated Gauges. High accuracy gauges maintaining calibration in the order of ± 0.25 to 0.75 per cent of range, over temperature extremes as wide as −40 to + 125F.



New All Stainless Steel Gauges. A.S.A. Grade B drawn case gauges with type 316 stainless steel Bourdon tube, movement, socket (welded), case and ring. Ranges up to 5000 psi.



New Pulsation Dampener Line. Access at side of unit to adjustable restriction in passage. No need to unscrew the gauge to fill top chamber with oil, or perform routine maintenance.

New Chemical Attachment Line. For protection against corrosive fluids. Resembles pulsation dampener in arrangement of adjustable restriction. If required, can perform damping function also.

ALSO NEW!

- Extensions to Pneumatic Receiver Line
- Sensitive Pressure Switch
- Gauge with External Zero Setting
- Gauges with Stainless Steel Diaphragms
- Portable Field Test Gauge

Find Your Nearest Distributor In The 'Yellow Pages'

UNITED STATES GAUGE

Division of American Machine & Metals, Inc., Sellersville, Penna.

USG®

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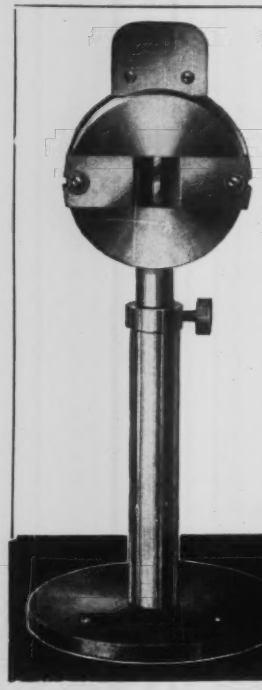

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

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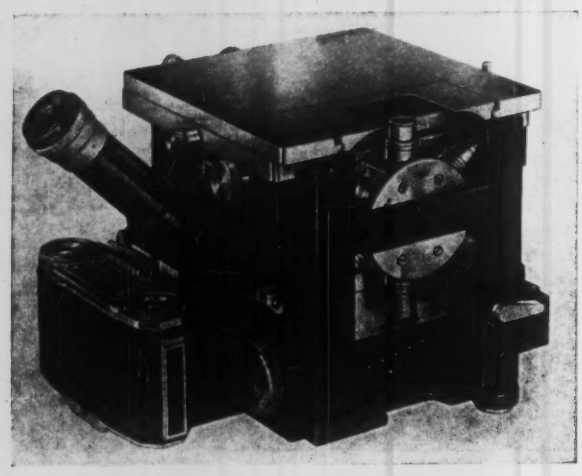

Write for detailed literature and specifications on this industrial microscope.

CARL ZEISS

WEST GERMANY

INTERFERENCE MICROSCOPE

For accurately measuring minute depths of roughness of super-finished surfaces, thickness of coatings, changes of surface structures due to wear, impact, stress, strain, corrosion, as well as for the studying of polished and etched metallurgical specimens.

Magnifications of 80x, 200x and 480x. Built-in Thallium and white light illuminators. Photography on 35mm film (1 x 1½ in.)

CARL ZEISS, INC.

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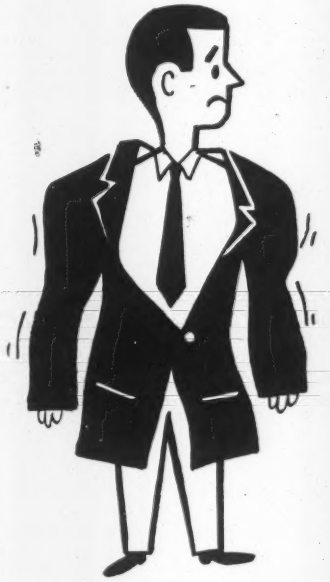


ARE YOU MAKING THE SAME MISTAKE IN DEPOSITED CARBON RESISTORS?

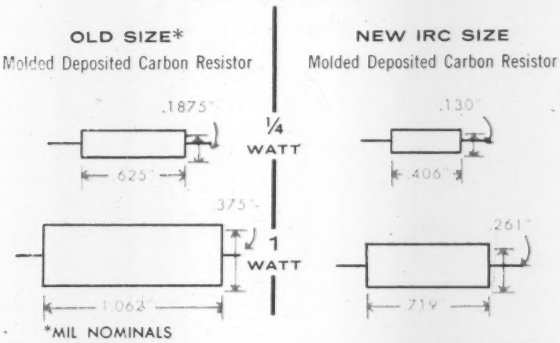
Switch to IRC Molded Deposited Carbon Resistors—"PRE-SHRUNK" for miniaturization.

If you have anything to do with miniaturizing components, be prepared for a pleasant surprise.

IRC has reduced the size of Molded Deposited Carbon Resistors in the 3 most popular wattage ratings at the same ambient, an improvement made possible through the use of a unique IRC alloy film and a new high-temperature coating.

This means that you can now choose a smaller unit with wattage equivalent to the one you formerly specified. Weight and space savings, as it happens, are especially significant in the most-used sizes.

COMPARE



*MIL NOMINALS

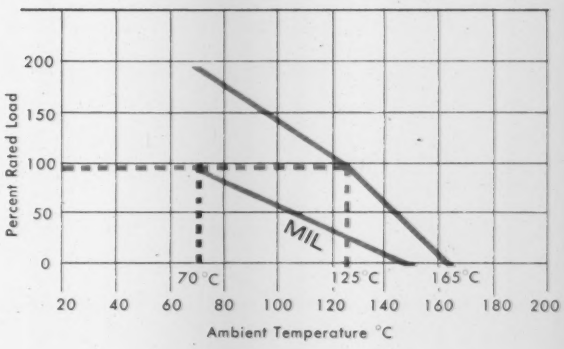
These SIZE REDUCTIONS also result in nearly corresponding weight reductions.

MIL Type	IRC Type	Length Nominal	Diam. Nominal	Min. Ohms	Max. Ohms	Max. Volts Continuous	WATTAGE MIL 70°C	WATTAGE IRC 70°C	WATTAGE IRC 125°C
RN60	MDA	.406	.130	10	5M	300	⅛	¼	⅛
RN65	MDB	.594	.203	10	5M	350	¼	½	¼
RN70	MDC	.719	.261	5	25M	500	½	1	½

IRC EXCEEDS MIL SPECIFICATIONS

IRC Resistors are designed for MIL-R-10509C Characteristic B requirements.

DERATING CURVE FOR IRC MOLDED RESISTORS



IRC HAS GREATER LOAD LIFE RESERVE

IRC Molded Deposited Carbon Resistors exhibit excellent heat dissipating characteristics. Size for size, IRC Resistors will run cooler under any load condition and take sudden overloads with very low permanent change. Load life is superior to that of hermetically sealed resistors which cost three times as much!

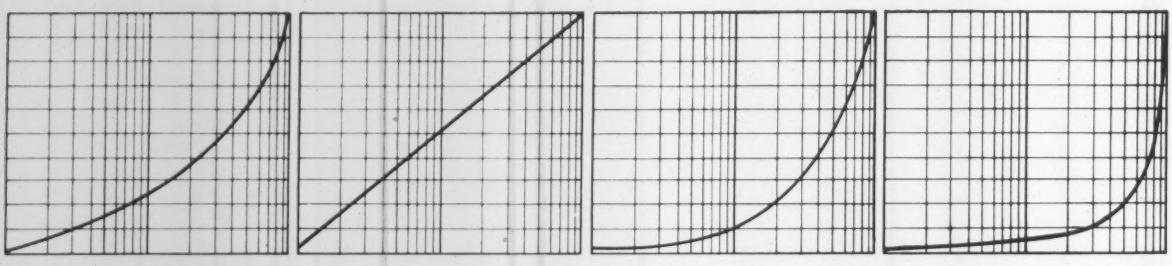
IRC HAS DOUBLE-BARRIER INSULATION

Resistance element is coated with a moisture-resisting material, then encased in a molded, break-resistant dielectric case which, though heavy-duty, is well within MIL size.

Write for Bulletin B-9C

INTERNATIONAL RESISTANCE CO., Dept. 445, 401 N. Broad St., Phila. 8, Pa. • *In Canada:* International Resistance Co., Ltd., Toronto, Licensee

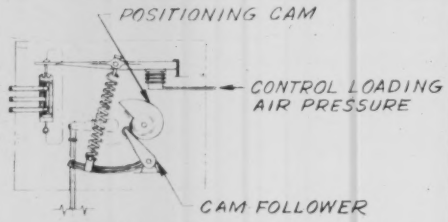
CIRCLE 51 ON READER-SERVICE CARD



TAKE YOUR CHOICE!

ANY OF THESE (and many more) CHARACTERISTICS ARE OBTAINABLE with DeZurik CONTROL VALVES

WITHOUT DISMANTLING THE VALVE!



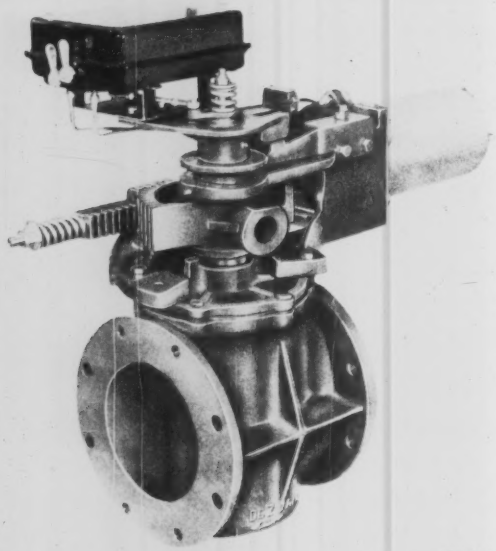
The positioning cam in the positioner is easily changed to vary the throttling characteristic. Cams can be supplied to produce virtually any desired curve, or they can be cut "on the job" to produce a characteristic tailored to the installation.

DeZurik Control Valves present an endless variety of possibilities to the instrument engineer. The characterizing feature of the positioner allows various positioning cams to be used which will produce almost any desired throttling characteristic.

The throttling characteristic may be pre-selected and the proper cam supplied with the valve from the factory, or the cam shape and resultant flow curve may be determined after installation of the valve. Changing cams is a simple operation and does not involve changing any valve part.

DeZurik Control Valves have extremely high rangeability, providing a wider control range than is available with ordinary control valves. Because of the port design and eccentric action, the flow characteristic is usable down to the shut off position.

In addition to this feature, DeZurik Control Valves offer dead-tight shut-off, higher capacity, leak-proof rotary stem seals, straight-thru flow and many other desirable features.



AVAILABLE NOW! GET THE COMPLETE STORY on DeZurik Control Valves. Ask the DeZurik representative in your area for Bulletin 150, or write Dept. CV.

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 52 ON READER-SERVICE CARD

book reviews

Recorder Survey: Recording Surfaces and Marking Methods, by George Keinath. National Bureau of Standards Circular 601, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., 41 p. plus iv, 10¼", clothbound 30 cents. Survey was undertaken to bring together available information on various problems and methods of recording scientific and technical data. This first volume deals with marking methods and recording surfaces. Foreword by A. V. Astin, director of NBS, mentions surveys that appeared in the May and August 1958 issues of *Instruments & Control Systems.*

Algebraic Theories, by Leonard Eugene Dickson [c 1926 Benj. H. Sanborn & Co.]. Dover Publications, Inc., 180 Varick St., New York 14, N.Y., 276 p. plus ix, 8", paperbound $1.50. Book is an unabridged and unaltered re-publication of the First Edition which was formerly published under the title *Modern Algebraic Theories,* showing the contributions of American mathematicians to the pure sciences around the first quarter of this century.

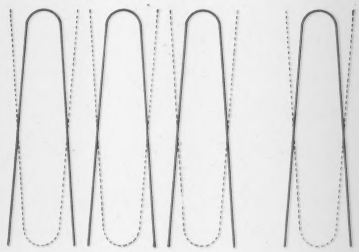
CIRCLE 170 ON READER-SERVICE CARD

Handbook of Automation, Computation and Control, Vol. II, edited by Eugene M. Grabbe, Simon Ramo, and Dean E. Wooldridge, [c 1959] John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1070 p. plus xxiii, 9", clothbound $17.50. Deals with computers and data processing in 31 chapters, describing computer terminology, digital computer programming, the use of digital computers and data processors, design of digital computers, design and application of analog computers, and unusual computer systems.

CIRCLE 171 ON READER-SERVICE CARD

R-L-C Components Handbook, by David Mark, [c 1959] John F. Rider Publisher, Inc., 116 West 114th St., New York 11, N.Y., 114 p. 8½", paperbound $3.50. This book complements the theory of R.L. and C. devoting 2 chapters each to each component. Presents the physical aspects, while the related chapter deals with commercially available components.

CIRCLE 172 ON READER-SERVICE CARD



LEADERSHIP IN MEASUREMENT

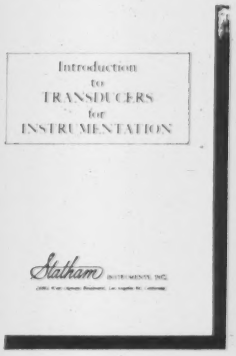
Statham's leadership in measurement is exemplified by a family of products distinguished for their reliability in missile, aircraft, industrial and nuclear instrumentation.

Researched and fabricated by the pioneer of the unbonded strain gage, many of these sensing instruments have been privileged to help make the U. S. space and nuclear power programs a dynamic reality.

Recognizing that no one line can include the ideal instrument for every purpose, Statham has further exercised the responsibility that devolves upon leadership by preparing an objective, illustrated booklet entitled "Introduction to Transducers for Instrumentation." Brief but scholarly, it will aid instrumentation and project engineers in surveying all 16 major transduction principles, including but not limited to those used in Statham products.

Write for it on your company letterhead. Other information on specified instrumentation areas or problems will be included at your request.

For prompt attention, address requests to Dept. ICS-864-1.



STATHAM INSTRUMENTS, INC.

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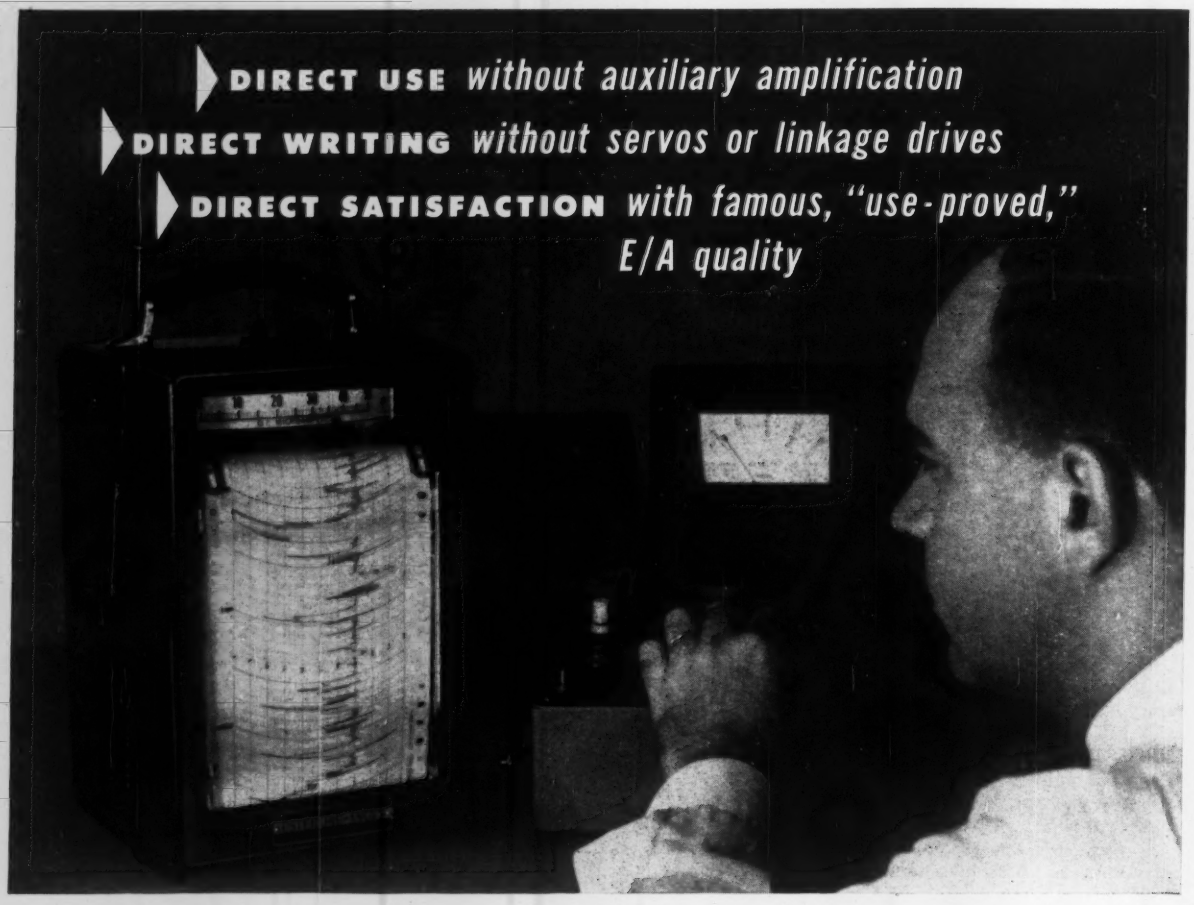
CIRCLE 53 ON READER-SERVICE CARD


DIRECT USE without auxiliary amplification
DIRECT WRITING without servos or linkage drives
DIRECT SATISFACTION with famous, "use-proved," E/A quality

You get them ALL with the new Esterline-Angus

RECORDING D.C. MICROAMMETER

Here's the recording instrument designed for universal use, with basic ranges common to numerous applications:

Ranges: 0 to 50 microamperes D. C. with approximately 200 ohms input resistance.
Also 0-10/50/200 millivolts D. C.

Power Supply: 120 volts, 60 cycles.

Response: 1 second, independent of external circuit resistance.

Here's the recording instrument with high stability, linearity, long-lasting reliability, and freedom from zero drift—desirable for most instrument applications . . . and here's why:

Direct writing eliminates maintenance of servo motors and linkage drives. Combines the famous E-A rugged, "use-proved" permanent-magnet moving-coil movement with a highly durable magnetic amplifier built with wide safety margins.

Extremely high sensitivity for direct use, without auxiliary amplification, in most electronic circuits.

Ruggedly built for continuously reliable results in rough use. Quickly and easily set up. Simple to maintain.

This new E/A D.C. MICROAMMETER is the recording instrument of *a thousand and one uses*—in every field of research and production.

Send for Catalog Section No. 41 and see how it can help you.

No. 1 in fine Graphic Instruments for more than 50 years

The Esterline-Angus Company

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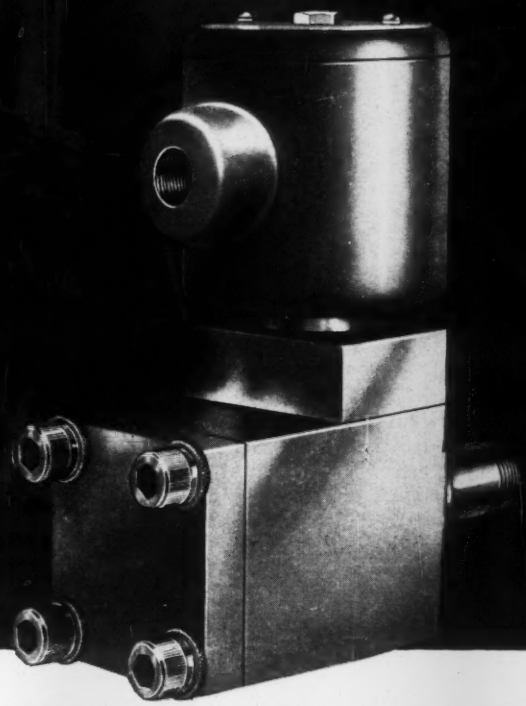
INDIANAPOLIS 6, IND.

CIRCLE 54 ON READER-SERVICE CARD

ASCO SOLENOID VALVES ARE ENGINEERED TO MISSILE GROUND SUPPORT REQUIREMENTS

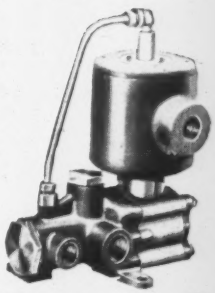


Tight Shut-Off at Pressures to 3000 PSI, Temperatures to Minus 350°F.

ASCO now brings you a family of solenoid valves, specially designed for missile applications with tough environmental or operational requirements. Two, three and four way valves are available with standard, explosion-proof or watertight solenoids; sizes range from ⅜" through 2½". Fluids handled include air, liquid oxygen, helium and nitrogen (liquid and gaseous). Valves can be supplied with continuous duty coil windings for 24 volts D-C, and for any other commercial voltages required. All types are packless (hermetically sealed), providing tight shut-off, with no external leakage to atmosphere.

Two Way Valves . . . normally open or normally closed, easily handle fluids at pressures to 3000 psi, temperatures to -350° F. Valves are stainless steel with teflon discs; most sizes are available with AN connections (Main Illustration-Bulletin 8223X).

Three and Four Way Valves . . . are suitable for piloting cylinder operated valves. Three way valves are also utilized for controlling single acting cylinders, and diaphragms; four way valves are used for controlling double acting cylinders. Unique poppet type seats and discs assure tight seating at pressures to 750 psi, temperatures to -65° F. Valve shown below (Bulletin 8344X) is suitable for 4 way applications, or may be used for 3 way installations by plugging one cylinder connection.



Proposals are submitted upon receipt of specifications—or an ASCO Engineer can help you in solving your ground support valving problems.

For additional information on ASCO Solenoid Valves for Missiles, write for Publication V5056.

Automatic Switch Co.

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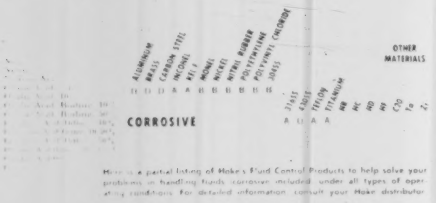
ASCO®

briefs

Corrosion Chart

There are numerous variables involved in the mechanism of corrosion. Among the more important of such variables are temperature, concentration, pressure, agitation, aeration and impurities. The corrosion

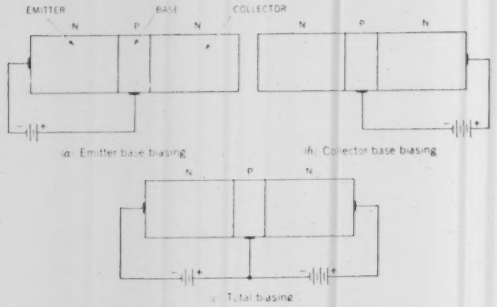


problem is made more complex by the addition of combination of these and other variables. Obviously the precise rate of attack under a prescribed set of conditions can only be achieved by actual performance tests under such conditions . . . (*From new slide rule calculator, Hoke Inc., 33 Piermont Rd., Cresskill, N.J.*)

FOR THIS LITERATURE CIRCLE 173 ON READER-SERVICE CARD

Understanding Transistors

We achieve a voltage gain in the transistor by virtue of the fact that the emitter-to-base resistance is low (because of the forward biasing between these two elements) whereas the collector-to-base resistance is high (because these elements are reverse biased). A typical value for the emitter-to-base resistance is about 500 ohms, and a typical value for the collector-



to-base resistance is about 500,000 ohms. The current that reaches the collector is 95 percent of the current leaving the emitter. If, now, we multiply the current gain (0.95) by the resistance gain 500,000/500, we shall obtain the voltage gain of the collector circuit over the emitter circuit. Numerically, this is

$$\text{Voltage gain} = \text{current gain} \times \text{resistance gain} = \frac{0.95 \times 500{,}000}{500} = 950$$

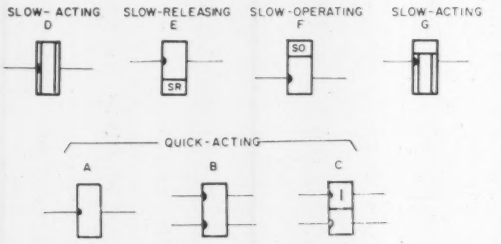
Thus, we see that while the current gain here is actually a loss, this is more than made up by the extent to which the collector resistance exceeds the emitter resistance. Furthermore, this overwhelming differential in resistance will also provide a power gain. This means that with a small amount of power in the input, or emitter-to-base, circuit, we can control a much larger amount of power in the output, or collector-to-base circuit. Both of these characteristics are important; without them the transistor would have only limited applications in electronics.

From the foregoing discussion we can formulate two rules concerning this and *all* transistors: (1) The emitter is biased in the forward, or low-resistance, direction. (2) The collector is biased in the reverse, or high-resistance, direction . . . (*From new 64-page "Handbook of Transistor Fundamentals," Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.*)

FOR THIS LITERATURE CIRCLE 174 ON READER-SERVICE CARD

Basic Relay Circuits

Certain basic relay combinations and characteristics achieve specific circuit results in telephony. These basic circuits have become the building blocks of automatic telephone switching. Adaptable to other automated tasks, they are finding new and increasing use



in industry every day. This book depicts a few such basic circuits . . . (*From new 36-page pocket-size booklet "Basic Circuits," including Relay Transfer Trees, Symbols, Slow-Operating and Slow-Releasing Circuits, Locking Circuits, etc., Automatic Electric, Northlake, Ill.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD

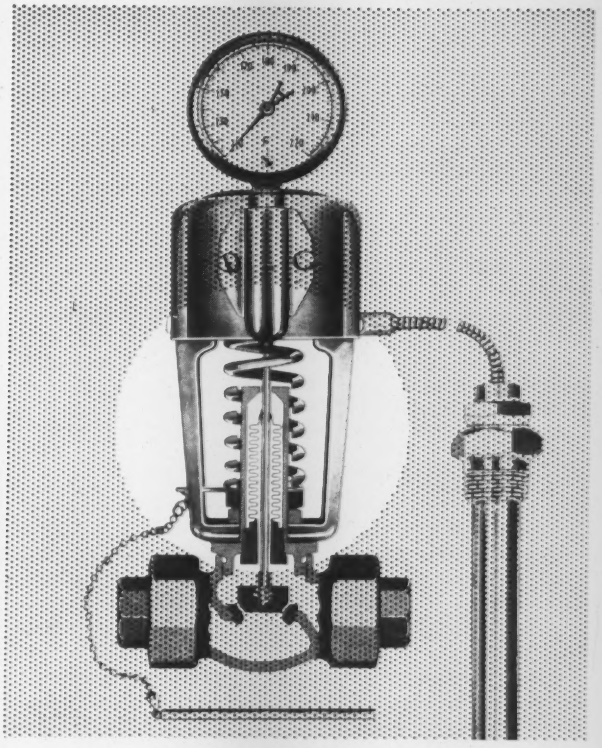
Games of Fun & Strategy

Kriegspiel: Kriegspiel (War Game) is a variant of chess which is unexcellent for action, unconscionable (but very legal) kibitzing, and preposterous situations. The play is more closely related to military tactics than to chess strategy, for neither player knows the actual position of his opponent's men . . . In the West the game has been popularized by and is largely identified with Rand Corp., of Santa Monica, where it is staple lunchtime recreation. While this corporation, contrary to popular opinion, did not invent the game (it was introduced there by emigrant mathematicians from Princeton a decade ago), it has influenced and defined the play, and the laws we shall use here for the most part those of Kriegspiel as played by Rand . .

The game is played with standard chess rules, two players, a referee, and kibitzers . . . whose role will be discussed.—(*From new 20-page "3C-Gram Book No. 1," explaining 6 unusual mathematical games, Computer Control Co., Inc., Mathematical Services Dept., 983 Concord St., Framingham, Mass.*)

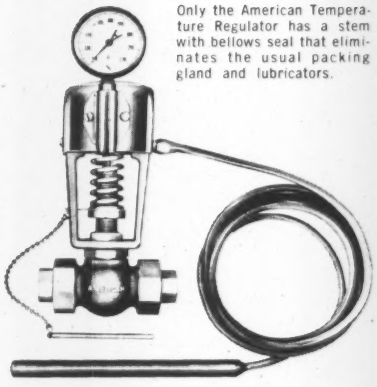
FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD

Temperature Regulation with Corrective Action within 1/10 of a degree



A friction-free bellows seals off the valve stem on the new American Temperature Regulator. Result: no stem binding to retard valve action, fastest possible temperature response.

The bellows seal makes practical a friction-free, nonleaking packless valve that needs no lubrication. This innovation plus an extra-long, preflexed adjusting spring marks the new American Temperature Regulator as the fastest acting, most stable available. Corrective action starts at less than 1/10 degree change at the bulb. And the adjusting spring allows unusual latitude in temperature settings.



Only the American Temperature Regulator has a stem with bellows seal that eliminates the usual packing gland and lubricators.

Compact design permits installation in "tight" locations. The dial thermometer on the indicating-type regulator can be positioned for easiest reading regardless of piping arrangements. Standardized parts and unitized assembly mean low initial cost. Maximum feasible use of stainless steel and a minimum number of components eliminate maintenance problems.

Get the best in economy, accurate temperature regulation, and dependability. Choose American Temperature Regulators. *Sizes:* ½" to 1½". *Temperature Ranges:* As low as minus 15°F. to 50°F.—as high as 240F°. to 350°F. *Valve:* Bronze body, stainless steel seat and disc. *Ask for Bulletin 114A.*

Phone your industrial supply distributor for counsel, service and prompt delivery from his local stocks.

MANNING MAXWELL & MOORE INC. TRADE MARK

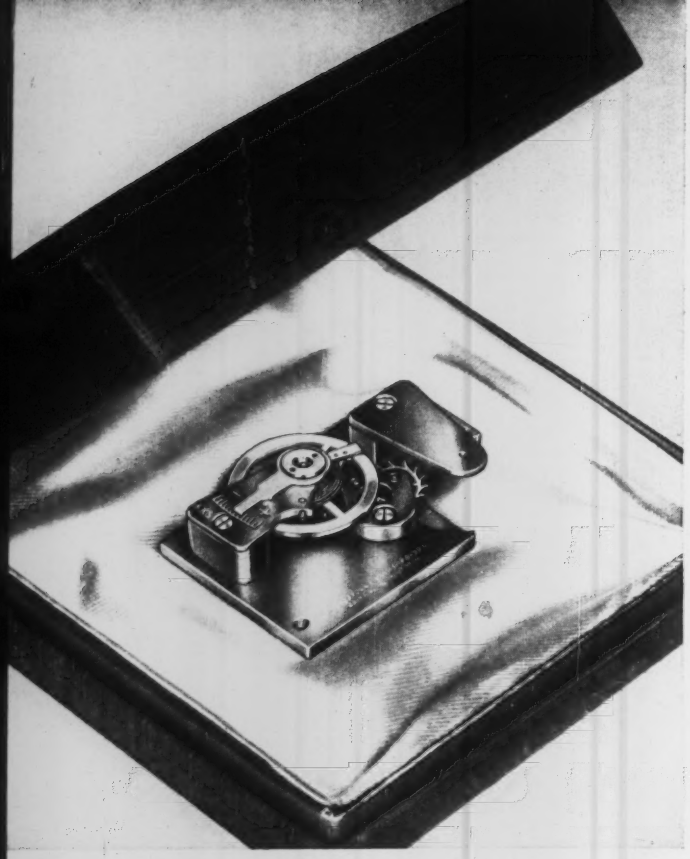
AMERICAN TEMPERATURE REGULATORS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 56 ON READER-SERVICE CARD



Now there's a New "Jeweled" Escapement in ROCKWELL CHART DRIVES

for greater accuracy and longer life

This jeweled movement brings fine watch quality to instrument timing

The introduction of a jeweled movement—the first ever used on a general industrial timing device made in the United States—makes the Rockwell more accurate than any unjeweled chart drive could possibly be. In addition to offering fine watch quality, the jeweled escapement requires less power to operate and is extremely durable, since seven hard jewel surfaces are provided to limit friction and wear.

You will benefit in many ways by using these jeweled movement chart drives for powering all your recording instruments. They adapt readily to fit into practically any instrument case while speed-changing turrets (see left) permit changing rotation rates at will. Write for full information. Rockwell Manufacturing Company, Instrument Division, Pittsburgh 8, Pa.

SPEED CHANGING TURRETS PROVIDE SEVEN DIFFERENT ROTATION RATES

The basic Rockwell Chart Drive has a main arbor rotation rate of 7 days. Economical snap-on turrets permit changing to 8-day, 15-day, 16-day, 24-day, 30-day, 31-day, and 24-hour rotation. No tools or special skills are required. You can even change chart rotation without removing the drive from the instrument.

JEWELED CHART DRIVES

another fine product by

ROCKWELL

CIRCLE 57 ON READER-SERVICE CARD

CONSIDER...

Products shown are twice actual size

Lockheed for electronic ceramics

The research, development and manufacture of miniature electronic ceramic components is centered in the new Electronic Ceramics Laboratory at Lockheed Electronics and Avionics Division (LEAD).

This facility is fully able to provide electronic ceramics to meet your particular specifications: MEMORY CORES, a whole family of square loop cores to suit computer and shift register applications: MULTI-APERTURE DEVICES (MAD), Cavitron equipment for the volume production of any geometry of MAD; RECORDING HEADS, of very dense materials with high flux density ground to a micro-finish; GARNETS, poly-crystalline yttrium-iron garnets with minimum line width and loss tangent; ALUMINA SUBSTRATES, of high mechanical strength, high electrical resistivity and low dielectric loss; CUP CORES, in any size to specified inductance and minimum temperature coefficient; HIGH "Q" MATERIALS, for use as inductors, tuning slugs, transformers—frequency ranges from 1 to 50 megacycles.

What are your requirements? Write . . . Marketing Branch, 6201 E. Randolph Street, Los Angeles 22, California. Telephone OVerbrook 5-7070.

Look to Lockheed for LEADership *in Electronics*

LOCKHEED ELECTRONICS & AVIONICS DIVISION

Requirements exist for staff and supervisory engineers

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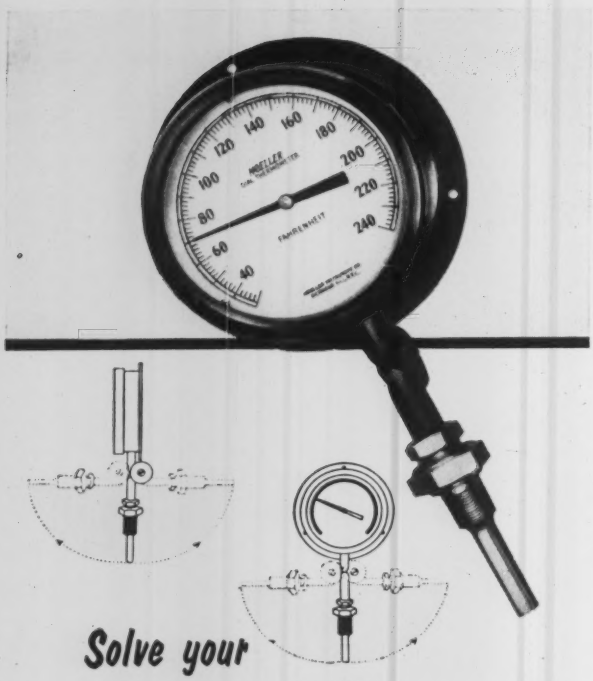

Solve your Installation Problems—

with

MOELLER

Multi-Angle Adjustable Dial Thermometers

This adjustable form feature — another MOELLER first, saves time in layout work, permits rapid installation regardless of type and position of equipment and reduces the number of spares. Large scales make these accurate Moeller temperature measuring instruments easy to read.

For full details mail the coupon, today!

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Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Dial Thermometers.

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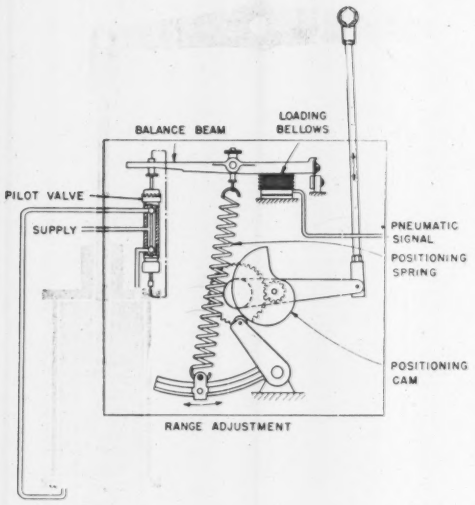
CIRCLE 59 ON READER-SERVICE CARD

Control Drives

The Positioning Relay illustrated is designed to accurately position the piston in the air cylinder in accordance with the pneumatic signal. By selecting one of the three positioning cams provided, practically any desired relationship can be established between the



pneumatic signal and the control drive position, thus compensating for undesirable characteristics of the damper or other equipment being controlled.

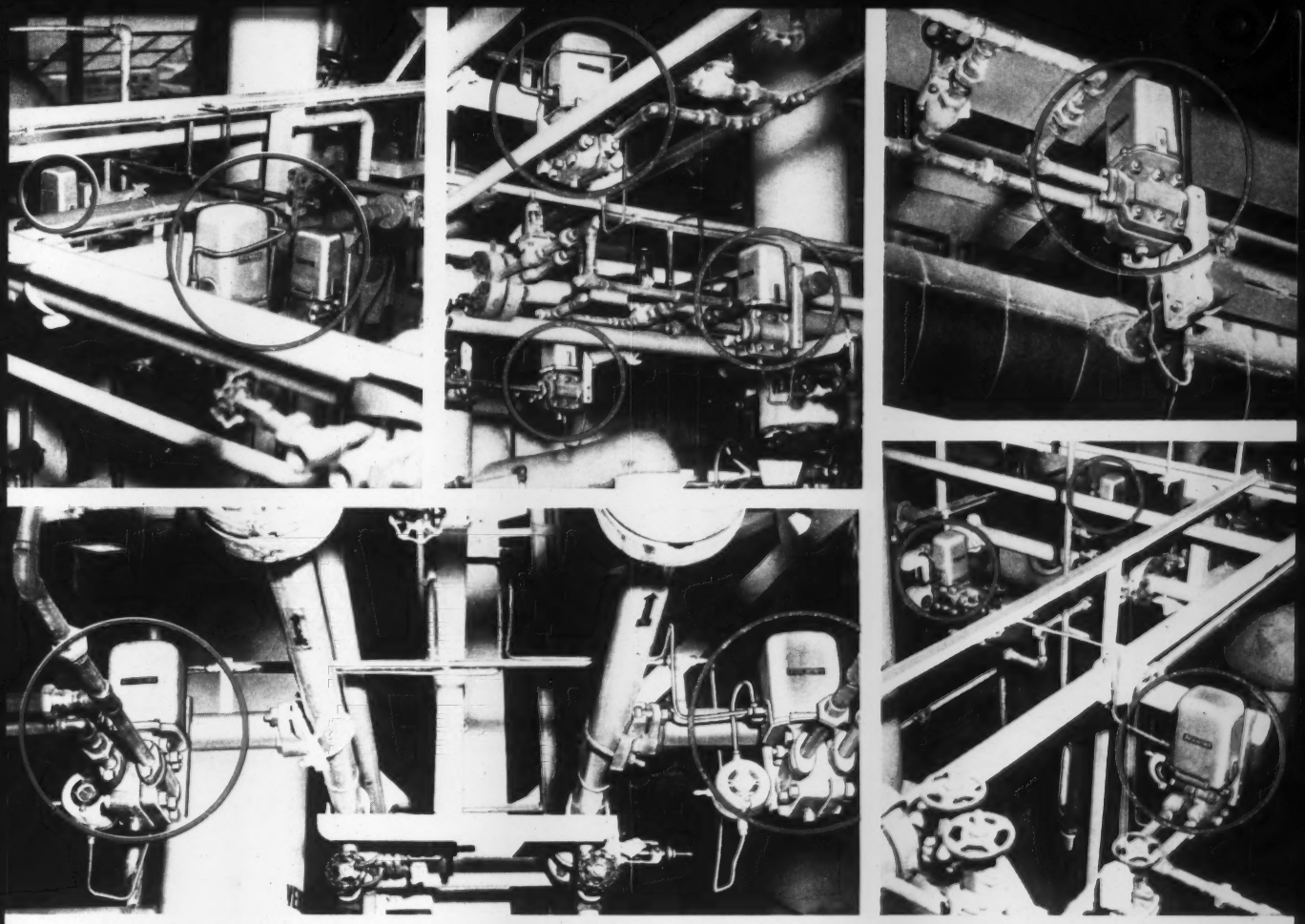
By reversing the cam on the Positioning Relay and interchanging the two air connections to the air cylinder, the Control Drive can be made to reverse its direction of travel for an increasing pneumatic signal. Standard SAMA pneumatic signal ranges 3-15 or 3-27 psig may be used . . . (*From new 6-page Product Specification P31-1 Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*)

FOR THIS LITERATURE CIRCLE 177 ON READER-SERVICE CARD

Calomel or Reference Electrodes

The capillary or drip type calomel is a general purpose electrode. The sleeve type is recommended where test solutions will permit only a minimum of KCl. The inverted sleeve type is recommended where a greater flow rate of KCl solution is required, such as may be encountered in slurries or with samples of high viscosity or excessive turbidity. The pressure type operates on pressure differential "breathing" principle and is recommended where pressures are greater than 5 psi or where the rate flow is excessive . . . (*From new 8-page Bulletin 912, Cambridge Instrument Co., Inc., 3732 Grand Central Terminal, New York 17, N. Y.*)

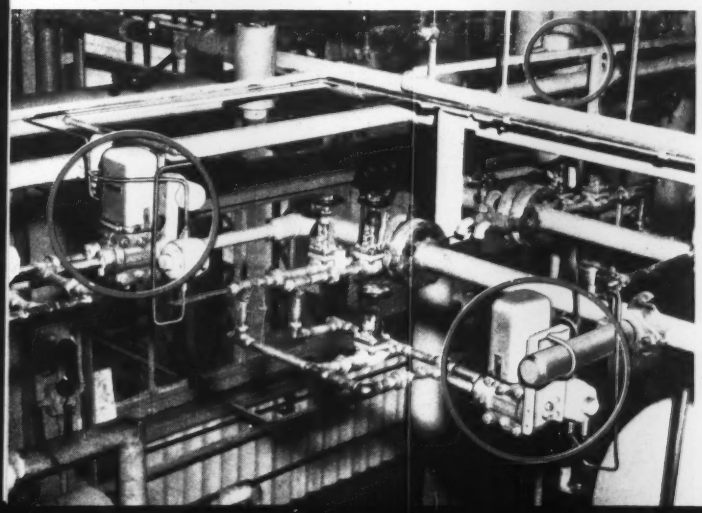
FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD



A few of the more than 100 Foxboro d/p Cell Flow Transmitters installed at Missouri Chemical Works of Hercules Powder Company, Louisiana, Missouri.

Hercules' Missouri Chemical Works reports:

"Foxboro d/p Cells* always accurate . . . never need re-calibration"



At Hercules Powder Company's 540-acre Missouri Chemical Works, there are over 100 Foxboro d/p Cell Transmitters in operation today — providing high-speed flow measurement and transmission throughout the ammonia, formaldehyde, methanol and pentaerythritol plants.

"Reliability is the big thing," according to Hercules instrument engineer J. J. VanShaik. "We can install a Foxboro d/p Cell and forget it. Once it's calibrated, we know it'll stay that way. We never even stock spare parts."

Hercules especially likes the Foxboro d/p Cell for flow control. "Gives us closer control," says instrument engineer H. McCombie. "Eliminates one possible source of inaccuracy and maintenance trouble in the control loop."

Let Hercules' experience be **your** experience — with Foxboro d/p Cell Transmitters as the basis for your control system. Write for full details in Bulletin 13-11A. **The Foxboro Company, 4611 Neponset Avenue, Foxboro, Massachusetts.**

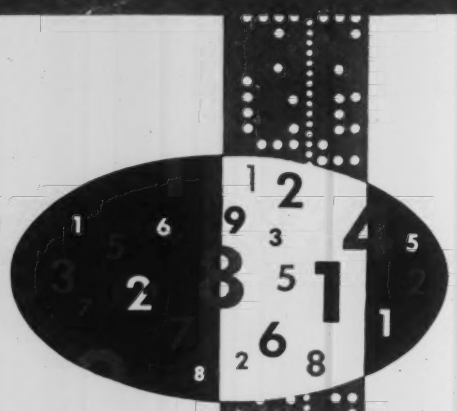
* Reg. U. S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

FIRST IN FLOW

CIRCLE 60 ON READER-SERVICE CARD



engineering the unusual in digital instrumentation

Peak engineering loads, tight delivery schedules, shortages of personnel . . . all place an added strain on overtaxed engineering facilities. If digital equipment engineering is part of this load, Franklin Electronics' Communications and Control Division can serve you best. Franklin's C & C Division, working in close cooperation with your engineering staff, designs and develops digital instruments and data systems to your specifications.

Whether the need is for a complete data acquisition and reduction system, a language translator, or a simple digitizer, you'll be pleased with how the C & C Division can ease your engineering load. But most of all, you'll be pleased with the final product . . . delivered on time . . . on a guaranteed performance basis.

Bulletin CC-220 describes the work of the C & C Division, its facilities, some of the equipment it has developed in the past . . . and how it can assist you now. Write for a copy. There's no obligation, of course.

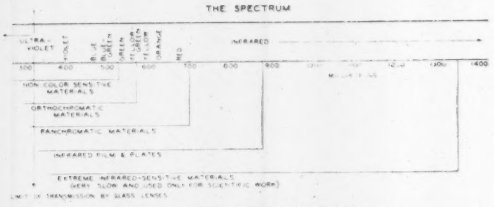
FRANKLIN electronics, inc

COMMUNICATIONS AND CONTROL DIVISION
VAN NUYS, CALIFORNIA

CIRCLE 61 ON READER-SERVICE CARD

Infrared and Ultraviolet Photography

Beyond the violet in the spectrum is radiation which is called the "ultraviolet," and which is of short wave length . . . At the other end of the spectrum, at wave lengths longer than the red, there also exists invisible radiation called the "infrared," meaning "below the red." . . . Usual photographic films and plates, even panchromatic ones, are not sensitive to infrared. Only



The spectral range of photographic sensitivity.

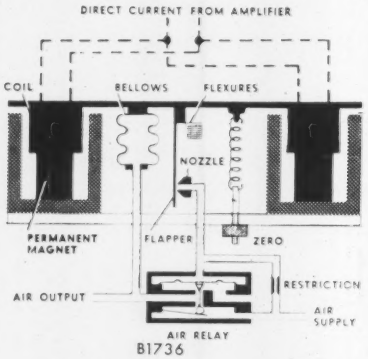
through treatment of the emulsion with special dyes can infrared sensitivity be conferred . . . There is no fundamental difference between the practice of infrared photography and that in which visible radiation is used . . .

Ultraviolet photography uses the same equipment as ordinary photography. Special lamps are required, however, and certain filters are needed. Special films and processing are not required, but a film of considerable speed is preferable unless very high contrast is needed . . . (*From new 52-page bulletin "Infrared and Ultraviolet Photography," Publication M-3 (price 50c), Eastman Kodak Co., Rochester 4, N. Y.*)

FOR THIS LITERATURE CIRCLE 179 ON READER-SERVICE CARD

EMF Pneumatic Transmitter

The EMF/Pneumatic Transmitter converts a d-c millivoltage measurement of temperature, speed, pH and many other variables to a proportional 3-15 psi



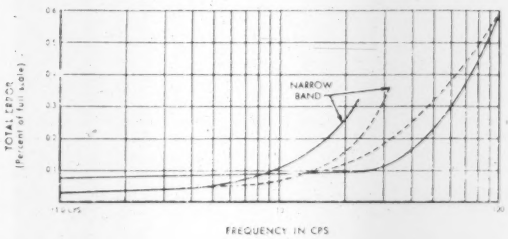
pneumatic output signal . . . The unit consists of an electronic amplifier incorporating a magnettor (d-c to a-c magnetic converter) and a direct current-to-air transducer . . . The EMF/Pneumatic Transmitter receives a millivolt signal from the measuring element (thermocouple, tachometer, etc.), converts it by means

of the magnettor circuit into a proportional 2000 cps a-c voltage, amplifies and filters the signal, and feeds it to a phase detector circuit . . . Heart of the Transmitter is the transducer shown schematically. An increase in current in the coils causes the flapper to approach the nozzle resulting in a back pressure in the nozzle supply line which actuates the pneumatic relay. Relay action increases the output pressure until the feedback bellows exerts a force on the armature bar to reposition the flapper relative to the nozzle . . . (*From new 4-page Bulletin 20-16A, The Foxboro Co., Foxboro, Mass.*)

FOR THIS LITERATURE CIRCLE 180 ON READER-SERVICE CARD

How to Judge Electronic Multipliers—and Why

Now that non-linear operations have become more common in analog computation, components like multipliers are often the decisive determinants of overall accuracy and computing speed . . .



Up to now no satisfactory equipment has been devised to measure the error developed when both inputs are varying as they do in a problem. However, a statement of dynamic error when one input varies sinusoidally while the other is held constant provides a fair estimate of actual performance. Total dynamic error can be calculated from a Bode diagram of phase error and amplitude error plotted separately against frequency; but, because total error is a vector sum of these two errors, the procedure is tiresome. Much to be preferred is a graph of total error vs frequency such as that appearing in figure . . . (*From new 7-page pamphlet "Speaking with Ease," Berkeley Div., Beckman Instruments, Inc., Richmond 3, Calif.*)

FOR THIS LITERATURE CIRCLE 181 ON READER-SERVICE CARD

Argon Leak Detector

New V.I.C. Argon Differential-sorption Leak Test Station is "first really low cost complete facility for fast detection and pin-pointing of leaks." Has high sensitivity, comparable to that of the mass spectrometer type detector, and can be used for the same general applications with lower investment. Uses inert Argon gas, as well as helium, which is in short supply and often restricted entirely. The sensing element detects all inert gases without machine modifications or adjustments.—(*From new 2-page Technical Data Sheet, Vacuum Instrument Corp., Huntington Sta., N. Y.*)

FOR THIS LITERATURE CIRCLE 182 ON READER-SERVICE CARD

FRANKLIN SERIES 1300

MODEL 1310N

ANALOG-TO-DIGITAL CONVERTERS

indefinite long-term stability

± one count accuracy

. . . two good reasons why Franklin's Series 1300 instruments are preferred in dozens of demanding applications. But there's more . . .

Series 1300 Analog-to-Digital Converters are available in four basic configurations—off-the-shelf, ready-to-operate. Matching accessories perform additional functions—convert codes, extend sensitivity, provide for a-c input signals, furnish automatic features . . . give the engineer complete freedom in his data system design.

For all the facts, request Bulletin 606.

ANALOG-TO-DIGITAL CONVERTERS

MODEL	* INPUT SIGNAL	READOUT	POLARITY AND DECIMAL INDICATION
1310	000.0 TO 120.0 V DC	VERTICAL	NO
1310N	SAME AS MODEL 1310	IN-LINE (NIXIE)	YES
1321	000.0 TO 120.0 V DC, 1 TO 100,000 MMF	VERTICAL	NO
1321N	SAME AS MODEL 1321	IN-LINE (NIXIE)	YES

* FOR SENSITIVITIES UP TO 100 MICROVOLTS PER DIGIT, SEE THE FOLLOWING LISTING.

FUNCTION AND RANGE EXTENDING AMPLIFIERS

MODEL	GAIN RANGES	GAIN SWITCHING			AUTOMATIC POLARITY
		LOCAL	REM.	AUTO.	
319RA	1, 10, 100, 1000	YES	NO	YES	YES
319R	1, 10, 100, 1000	YES	YES	NO	NO
319	1, 10, 100, 1000	YES	NO	NO	NO
318RA	1, 10, 100	YES	NO	YES	YES
318R	1, 10, 100	YES	YES	NO	NO
318	1, 10, 100	YES	NO	NO	NO

FRANKLIN electronics, inc.

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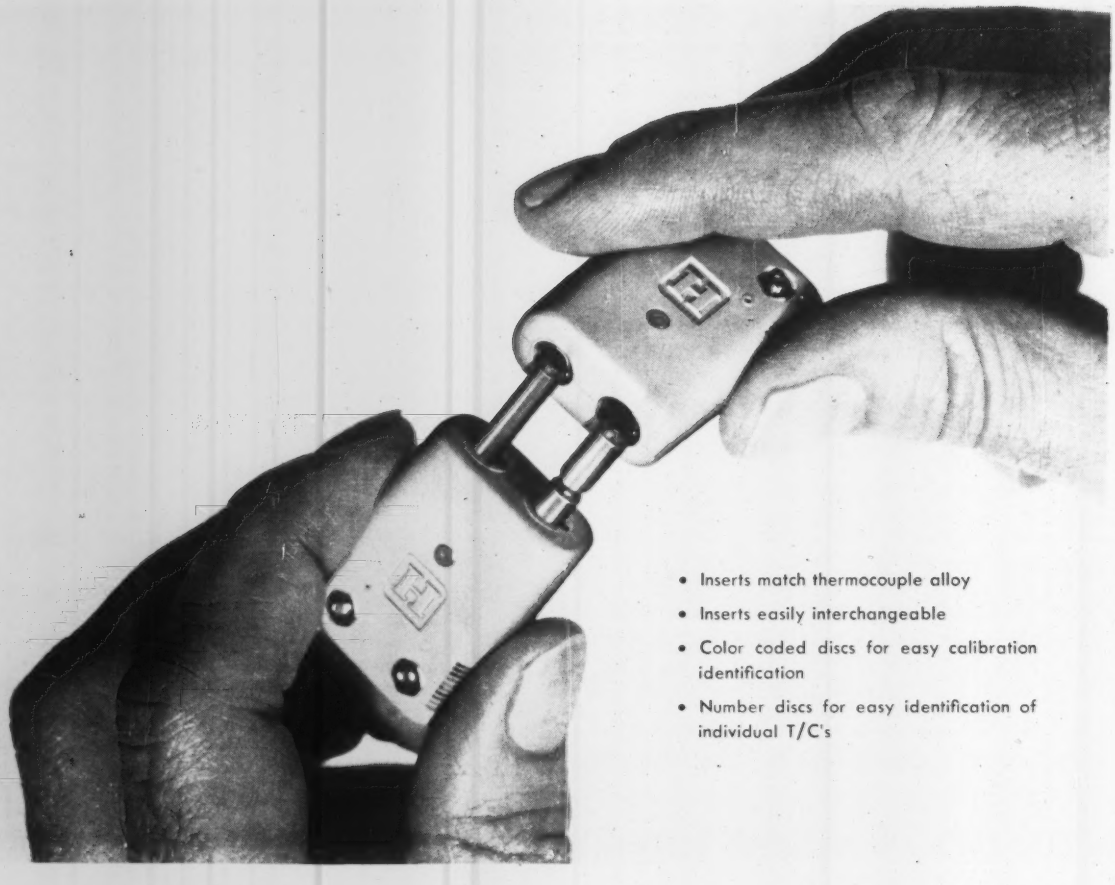
CIRCLE 62 ON READER-SERVICE CARD



- Inserts match thermocouple alloy
- Inserts easily interchangeable
- Color coded discs for easy calibration identification
- Number discs for easy identification of individual T/C's

*QuiK-Konnect** thermocouple components

For accurate, swift, and foolproof connection of thermocouples to extension wire

New *QuiK-Konnect* plug and jack bodies give fast, easy, and foolproof extension wire connections in plant, laboratory or test cell installations.

Inserts have different diameter positive and negative poles, for foolproof connection . . . are extremely easy to remove for field calibration change or replacement. Various tube adapters are available to protect small-diameter thermocouples, and cable clamps can be supplied to protect extension wires from fraying or tearing.

The *QuiK-Konnect* line, in addition to plugs and jacks, includes:

1. Single-jack panel that fits ¾-in. knockout.
2. 4-point jack panel that fits standard electrical outlet box.
3. Multiple jack strips.
4. Custom-built multiple jack panels.
5. *QuiK-Kords** for patch programming multiple jack panels.

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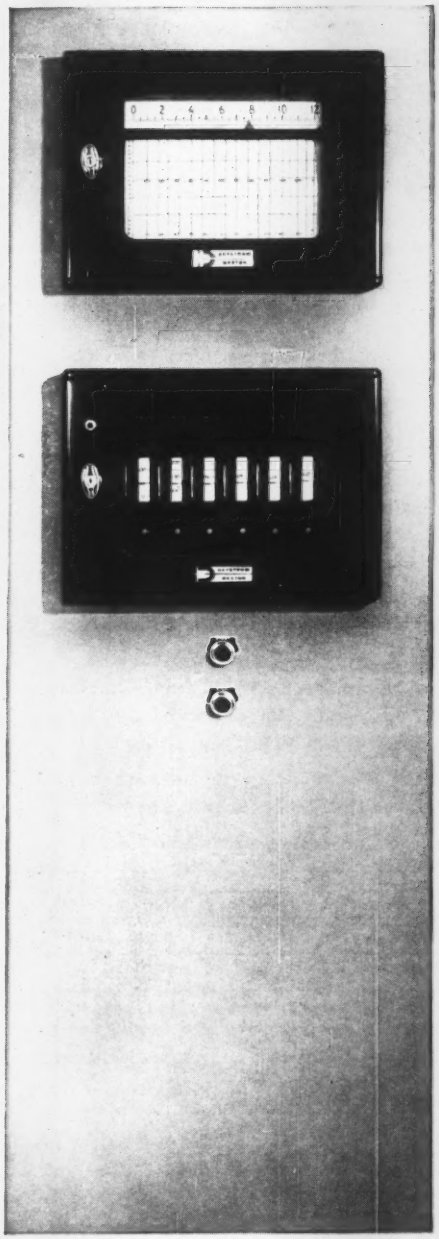
CIRCLE 63 ON READER-SERVICE CARD

1+1 = 6



CORRECT!

Maybe not in second grade, but correct with this new Daystrom-Weston economy "package": the Model 6134 Multi-Point Controller and Model 6702 Multi-Point Recorder combination.

Up to six individual recording controllers can now be replaced by this two-unit set-up.

Up to 50% in cost reductions can be realized over individual units when 6 points are specified for each instrument. As many as 18 additional points can be added to the recording unit if desired.

Savings are not limited to initial cost alone. Compactness, flexibility and accurate, reliable operation free from maintenance worries all contribute to substantial long-range savings as well.

Both independent units employ the exclusive D-PAK® Constant Current Source, eliminating many conventional components such as batteries . . . standard cells . . . standardizing mechanisms. Their unitized design makes for easy accessibility of interior parts . . . provides precise 2- or 3-position electric contact control.

Two distinctly separate circuits afford dual protection against overtemperature. Alarm circuits set for individual points in the Recorder provide high or low temperature cut-off as desired. Two separate or one common thermocouple can be used for each point – as the installation demands.

Control packages, including panels and accessories, can be suited to your own specific application.

For further information, contact your local Weston representative . . . or write to Daystrom-Weston Sales Division, Newark 12, N. J. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.

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CIRCLE 64 ON READER-SERVICE CARD

Case Type No. 1279.

Case Type No. 1379 is Alumalife, while similar case Type No. 1079 is Cast Iron.

Case Type No. 1377.

In such cases DURAGAUGES® naturally serve longer

You have a choice of three case materials—Alumalife®, a special aluminum alloy, Cast Iron, rugged and durable, Phenol, tough and rigid plastic—plus the unique "Maxisafe" design when you specify Ashcroft Duragauges.

All three case materials use a chrome plated, die-cast retaining ring to keep out harmful fumes and dirt. Case construction simplifies servicing—the entire system can be easily removed for recalibration or repair.

The "Maxisafe" case provides absolute protection to the viewer, easy and quick access to the tube and movement assembly. An integrally cast solid wall separates the dial from the tube and movement. A safety cover plate on the back is held in position by a knurled knob.

Regardless of your gauge case requirements, there's an Ashcroft Duraguage to do the job. Contact your local Ashcroft Gauge Distributor for complete facts.

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi.

CASE MATERIALS, TYPE NUMBERS, MOUNTING AND SIZES

CASE	TYPE NO.	BACK FLANGE	MOUNTING		CONNECTION		DIAL SIZE
			WALL	FLUSH	LOWER	BACK	
Black Alumalife	1379	Yes	Yes	Yes	Yes	Yes	4½", 6"
Black Cast Iron	1079	Yes	Yes	Yes	Yes	Yes	4½", 6", 8½" 10", 12"
Black Phenol, Turret Design	1279	No	Yes	Yes*	Yes	Yes	4½", 6", 8½"
Black Alumalife**	1377	No	No	Yes	No	Yes	4½", 6", 8½" 10", 12"

*May be flush mounted by using Flush Mounting Ring, Catalog No. 1278.
**The 10" and 12" dial sizes are made in cast iron only.

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CIRCLE 65 ON READER-SERVICE CARD

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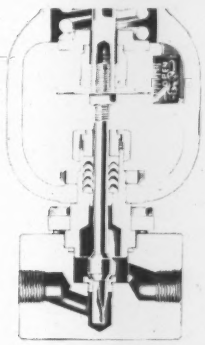
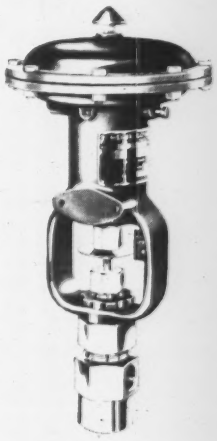
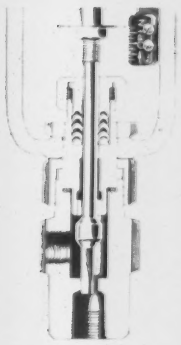


Type 510-B valve with globe body and bolted bonnet construction.





Type 511-BA valve with angle body and a union nut bonnet.

CONSTRUCTION AND SPECIFICATIONS	
Valve Body Sizes	1/2", 3/4" and 1" only with screwed end connections.
Inner Valve	Micro-flute or Micro-form.
Orifice Sizes	1/4", 3/8", 1/2" and 3/4" for the 1" size body. 1/4", 3/8" and 1/2" for the 3/4" size body. 1/4" and 3/8" for the 1/2" size body.
Max. Body Pressure	1500 psi at 450° F.
Overall Dimension	Approximately 15" with the Type 510 or Type 511 topwork on either a "B" or "BA" body.

For complete information write for Bulletin 57 B.

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CIRCLE 66 ON READER-SERVICE CARD

editorial

Engineering Education Now and Thirty Years Ago

JAMES C. COE

A professional teacher at the university level left the academic world to work in industrial research and development where, for thirty years, he observed and directed the work of engineering graduates. Then he returned to the academic world, to teach in a university.

His comparison of the students of thirty years ago with those of today reveals weaknesses in today's students, instructors, and education philosophy. These weaknesses do much to explain both why our engineering education is not meeting our needs, and why the efforts (and money) being devoted to remedies are not succeeding.

One basic reason is that increasingly more theory is being piled on an increasingly weaker foundation of true basic understanding. Technical measurements and instrumentation could do much to lay a firm foundation of understanding and practicality on which advanced theory could be constructed. The moral of the following report is that the more abstract the theory, the greater the need for a firm foundation of practicality.—ED.

NOT ALL the changes in engineering education during the past thirty years have been for the better. Although a great deal more is expected now in engineering education than thirty years ago, students of today are neither better prepared nor brighter than their parents, the students of 30 years ago.

In this interval of a generation, not only have new fields been opened, which have changed engineering curricula, but a great deal of information has been quantitized. The new fields include both newer applications and extension of old fields, so that more material is being squeezed into the four years of college.

In order to cover this quantitizing of old fields and extensions into new ones, present practice is to make courses more abstract, but with less emphasis on basic physical facts and physical concepts which may be necessary to understand the abstract theory and mathematical treatment. Despite the fact that basic physical concepts should be brought home *before* taking off into abstract flights of theory, the increasing demand to cover more subject matter causes these physical fundamentals often to be crowded out by abstract theory. In other words, the student is required to cover more theory with less concrete background upon which the theory is built. This greater abstraction is becoming increasingly remote from the physical world.

The Instructor

The higher scholastic attainments required of present-day instructors, coupled with reduced emphasis on teaching ability, is one reason for this development. Many such instructors have a tendency to pass over fundamentals and physical concepts, and to bring in theory of an advanced and graduate level before it can be assimilated. This further aggravates skimming over material in order to cover a requisite number of chapters.

Many instructors have a feeling that the student is the customer and must be pleased. Often they are required to feel that way; students find sympathetic ears in the offices of deans and department heads, and pressure is brought to bear on the instructor to make courses "easier." Academic freedom suffers in such an atmosphere. The instructor who gets along best is the one who makes his student think he is getting a lot, with little effort on the part of the student, with few problems to jar his equanimity, and an easy examination to wind up the course. On the surface everyone is happy—for the time being.

Another trend is that instructors consider themselves lecturers rather than teachers. Blackboard work by students is practically unknown and is considered impractical in the urgency to cover the necessary textbook material. Homework is pointed more toward reading the text or studying notes than in doing problems.

Blackboards can serve a useful purpose to both student and instructor in uncovering weak points, but blackboard time is seldom taken from precious lecture time; greater reliance is given to simple problems done at home. But students often "solve" problems at home without understanding the material. Further, if problems are assigned for homework, less study of text can be expected.

Yet problem solving is a considerable part of engineering work; learning to solve problems is one of the best parts of an engineering education. Problems and examination show students that they really

do not understand the subject as well as they thought they did; and they show the instructors how well they are getting the material across. But grading problems and and exams requires extra effort, and many instructors do not want to have the students brought up short—if the subject isn't being put across, a reflection on the instructor may result. The result is increasing reliance on a minimum number of stereotyped, simple problems, done at home.

The Students

The manners and "ordinary" countesy of students have deteriorated radically. Yawning openly and noisily, coughing and sneezing into the open, interrupting the instructor, grumbling and wisecracking are not uncommon. There are far more temper tantrums. There is an increasing tendency to quibble about previous orders and about grades. To give an assignment verbally is to invite debate and contradiction. One soon learns to write assignments on the board or to pass out typewritten copies to minimize contention. Even then many try to "negotiate" for higher grades. It is increasingly difficult to be sufficiently specific and "quibble proof."

Some of this can be ascribed to the point system, in which an A gives 3 honor points, a B gives 2, etc., but there is too much concern about grades, and copying is rampant. Although this is a deficiency of the point system it is a greater indictment of the student. Perhaps even our society's respect for "success at any price" is a factor here.

Further, many graduates believe the theory which they have received is the beginning and the end, the substance rather than a starting point and a guide to point the direction of effort in practical work.

Results

One of the results of too much theory based on a weak foundation is that students rely more on their instructors and facilities. In laboratory work they require more guidance and specific instructions. They are less able to solve practical situations. With the present deemphasis on problems and blackboard work, they are bewildered when confronted with situations in the laboratory.

A generation ago students were attracted to engineering courses because of mechanical aptitudes and an interest in "engineering." Today many are attracted by stories that industry is short of engineering and long on pay. Regardless of what attracts students to engineering, too many have the idea that an engineering education can be obtained by absorption or some osmosis process requiring little effort beyond studying theory.

Conclusion

Students today cover more material but understand it less. They come to know more and more with less and less real competence. They are in trouble when, after graduation, they are confronted with problems for solution.

There is not enough emphasis on fundamentals and on the physical basis upon which theory should be built. Too much material is covered in a superficial manner. Instructors often take the easy way out. Students of today, while thinking that they are receiving a good education, are less courteous, more demanding, less thorough, less self-reliant, and less capable than their parents.

Instrumentation Standards and Calibration

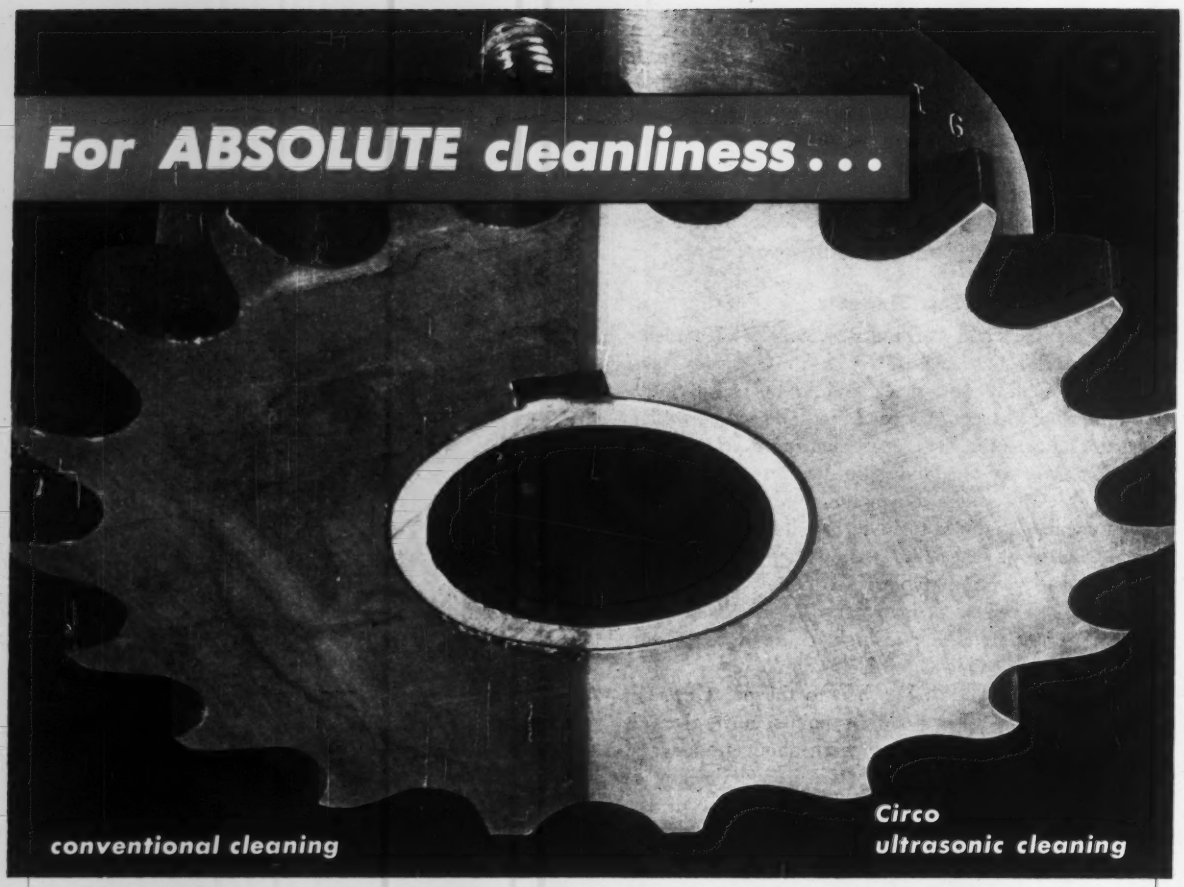
THAT industry and the armed forces depend on accurate standards of measurement is an oft-stated truism—but the *lack of practical information* on standardization and calibration practice is well concealed behind the mass of material apparently devoted to the subject. In other words, much is spoken, too little done.

The problem emerges from a survey recently conducted by the Quality Control Committee of the Aerospace Industries Association, sponsored by the Sperry Gyroscope Company. Sixty eight firms (almost all over 500 employees) were queried as to sources, steps and frequency of instrument calibration, in the fields of (1) dimensional, (2) optical, (3) temperature and humidity, (4) shock, vibration and force, (5) microwave, (6) radio frequency, (7) electrical, (8) pressure, vacuum and flow, (9) infared, and (10) radiological instrumentation. (One significant omission from this list is that basic industrial variable—weight.) This survey will be reported in detail in future issues.

One question (question 4) of the survey asked "Should text material . . . and other educational matter concerning calibration of standards be made available to industry from some central source . . .?" The answer: Yes—61; No—1.

The one source that has had the most practical material on standards instrumentation has, over the years, been *INSTRUMENTS AND CONTROL SYSTEMS*.

INSTRUMENTS AND CONTROL SYSTEMS has long recognized the need for practical standards instrumentation, and much of our editorial has been devoted to this subject. Two entire issues (January and September) were devoted exclusively to basic electrical measurements, with emphasis on the standards used to calibrate the instruments. A special issue also was devoted to weight techniques and standards. Still another to accelerometers and calibration. Our future editorial policy will remain as it has in the past—dedicated service to *practical instrumentation for measurement and control*, with emphasis on standards and calibration.



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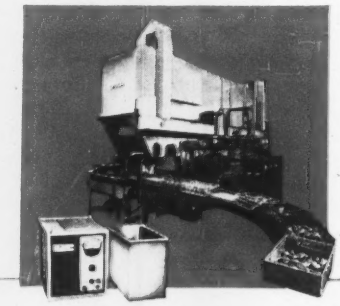

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CIRCLE 67 ON READER-SERVICE CARD

CIRCLE 68 ON READER-SERVICE CARD →

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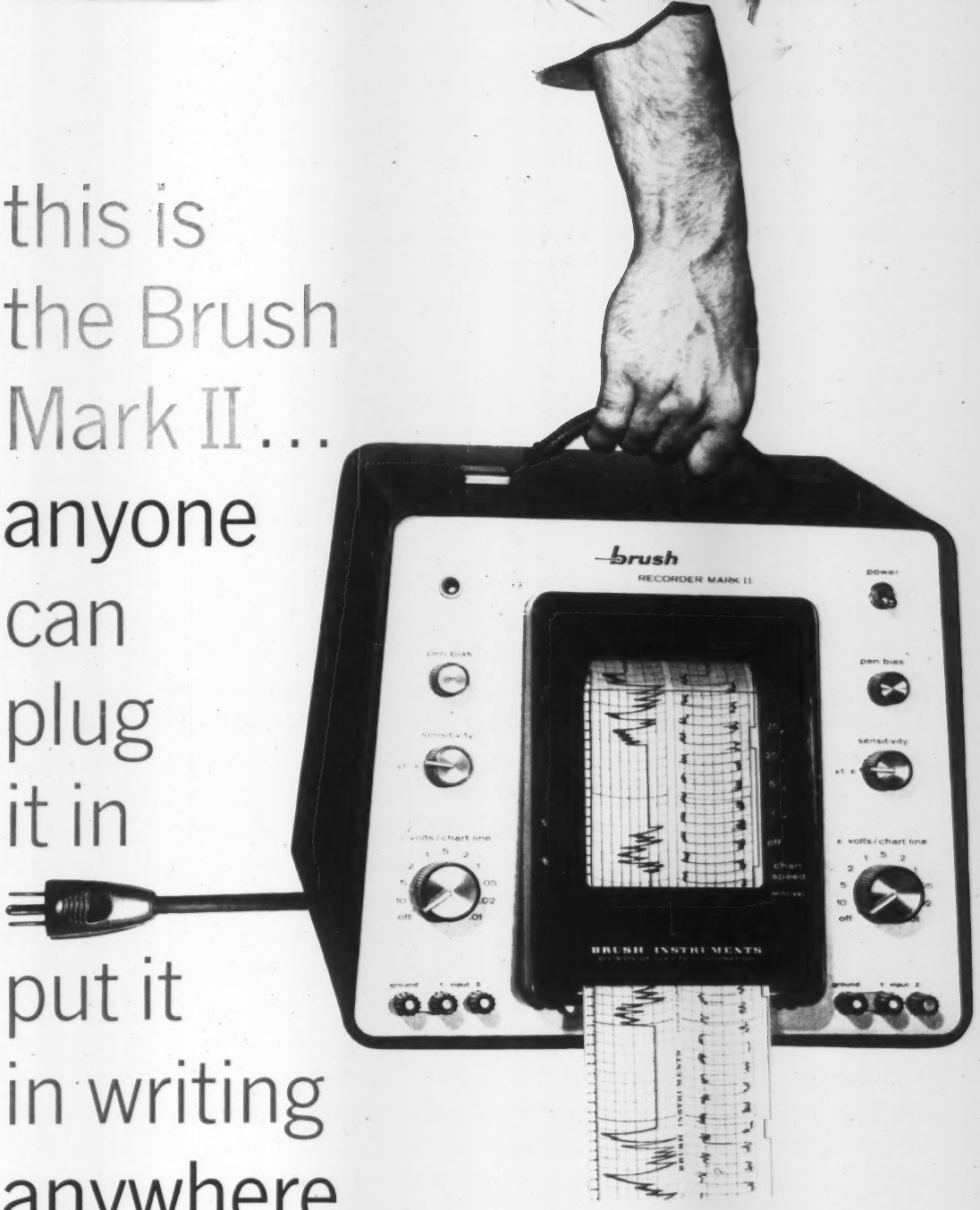

There is no direct writing recorder on the market that approaches the compact Mark II in sheer usefulness. It is a completely integrated engineering tool that can be operated by anyone . . . in the shop or in the field . . . for countless research or design requirements. Every function necessary for uniform, crisp, easily reproduced readouts is "built-in". The Mark II gives you two analog channels plus two event markers; 4 chart speeds; DC to 100 cps response with 40 mm amplitude; 10 mv/mm sensitivity; high input impedance. Immediate shipment from stock. Call, write or wire for complete details.

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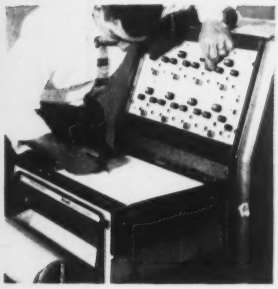
37TH AND PERKINS CLEVELAND 14, OHIO

for direct writing recording systems no one is as qualified as Brush



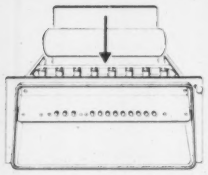
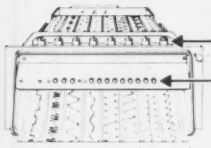
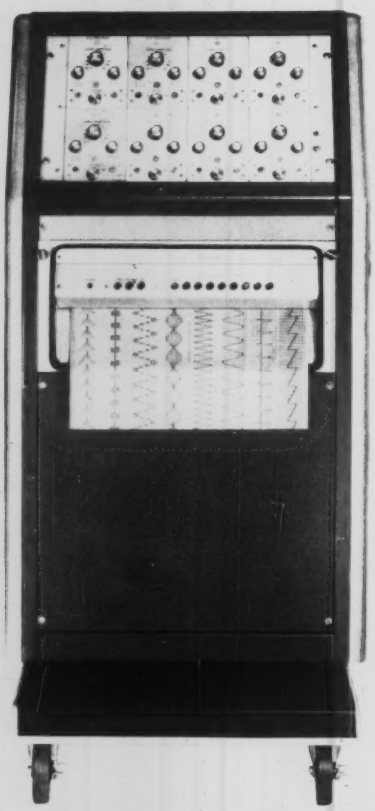


Chart paper loads from top



Trace contrast control

Simple pushbutton speed selection



Why? Simply because Brush recording systems such as this 6-8 channel unit incorporate all of the known refinements in the art of recording by direct writing. No comparable system in existence today is as compact . . . as simplified . . . as reliable . . . as versatile. Note slide-mounted oscillograph and interchangeable "plug-in" signal conditioners that provide four vital functions in addition to amplification: high input impedance, zero suppression, attenuation and calibration.

Instantaneous rectilinear presentation gives clear, uniform and reproducible traces for precise readout of telemetry, computer, ground control and other data gathering operations. Further, this functionally designed system has a "pull-out" horizontal writing table for convenient annotation and reading . . . without turning off the recorder! Check these and many other advanced features for yourself and you'll see why *no one* is as qualified as Brush. Call, write or wire for complete details.

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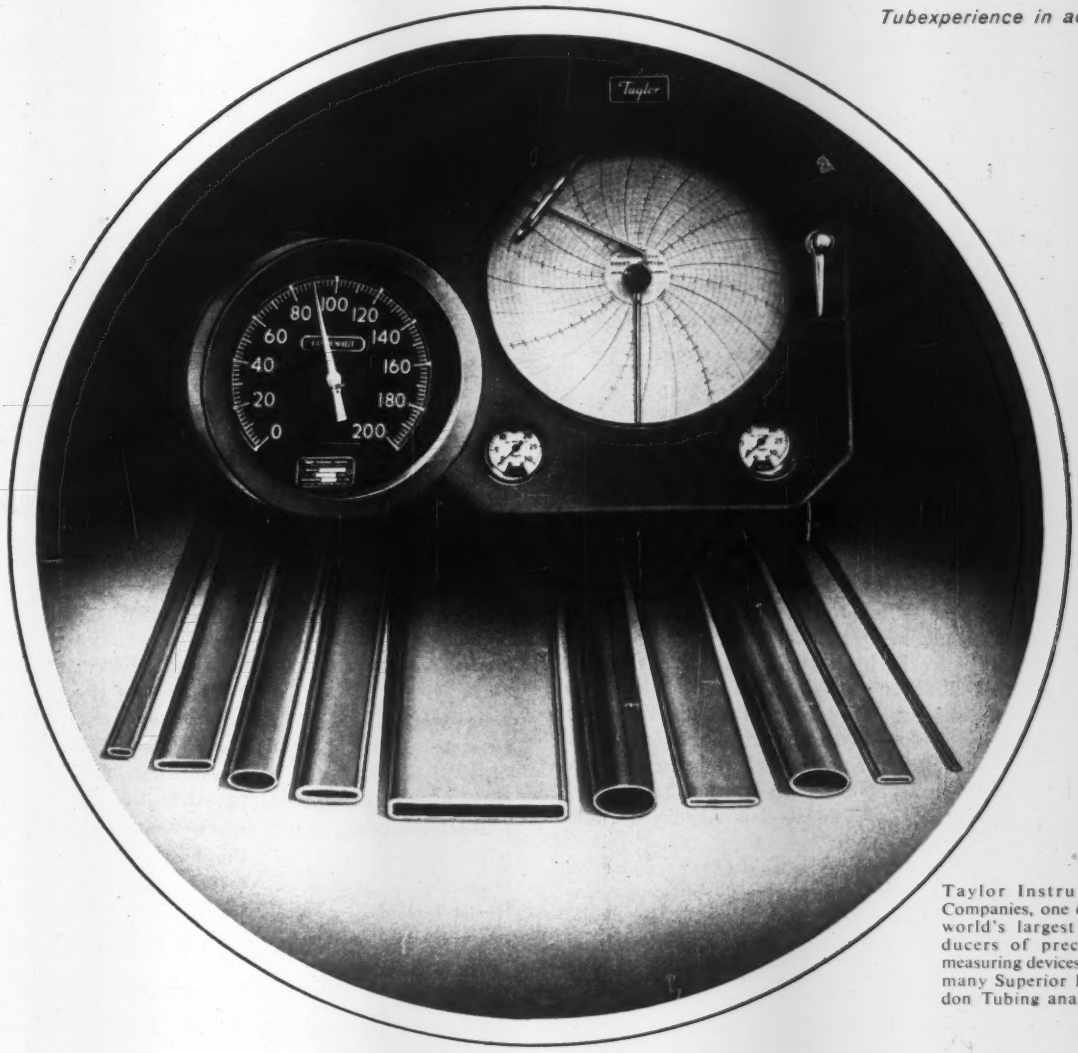

Taylor Instrument Companies, one of the world's largest producers of precision measuring devices, uses many Superior Bourdon Tubing analyses.

Rx for accurate indication of pressure and temperature: Bourdon Tubing by Superior

Bourdon tubes with consistent spring rate and minimum set, drift and hysteresis are essential to precision measurement of pressure in modern indicating, recording and controlling instruments. The tubing from which they are made must be free of inclusions and seams, carburization or decarburization, rough or corroded surfaces, and variations in wall thickness. Superior Bourdon Tubing has the extra qualities that permit interchangeability of Bourdon elements in the field with maximum ease, simplify range changes, require only linkage adjustment.

Typical of the care exercised in the manufacture of Superior Bourdon Tubing is the use of weight control to check tubing dimensions. This fast, precision method of checking average wall or ID enables us to provide tubing with unusually high overall uniformity. No matter how many Bourdon elements you make from Superior tubing, you get a uniform deflection rate in every case.

Superior offers a wide range of analyses, including strain-hardened, precipitation-hardened and heat-treatable materials for the fabrication of Bourdon Tube elements. Write for a copy of Bulletin 41, giving detailed information. Write Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

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CIRCLE 69 ON READER-SERVICE CARD

← **CIRCLE 68 ON READER-SERVICE CARD**

Data Loggers

This survey of loggers shows the great variety of types and sizes available to the user.

MILTON H. ARONSON

FOR FOUR YEARS, since October, 1955, this publication has featured a continuous series of articles on basic digital techniques. The first 21 installments resulted in the book *DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL*, by Klein, Morgan and Aronson, 1958. Since that time, the series has continued with discussions of digital readouts, scanning mechanisms, printers, etc. In this and the next few issues, these components will be shown assembled into their ultimate applications—data loggers and control computers.

No clear distinction can be made between loggers and computers—loggers usually perform some computations, and control computers almost always have logging functions. However, in the interest of rational examination, we shall define the logger as that system comprising multichannel analog and digital inputs, input scanning mechanism, printout and readout mechanisms, and computing ability below the integro-differential level. The computer system thus becomes a similar system but with computing abilities in the integro-differential realm.

The lack of clear lines between these classifications is indicative of the lack of knowledge concerning the best method for selling and applying data systems. Cost data is scarce; only a few of the many companies offering logging and computing systems really know all the costs associated with the engineering, sales and application of the system. (Many users of these systems have benefitted by obtaining large amounts of engineering assistance at far less than the cost to the instrument manufacturer.)

It must be mentioned that the extraordinary attention paid to "systems" by the technical press has literally forced many instrument suppliers into offering unfamiliar systems services. One result has been the below-cost engineering services mentioned; another is that the prospective user has a large number of possible suppliers for his logger or computer system. For example, the May issue of this publication reviewed the following suppliers of printers and printout mechanisms:

American Telephone & Telegraph	Panellit
Anelex	Potter Instrument
Beckman-Berkeley	Presin
Bendix	Radio Corp. of America
Benson Lehner	Remington Rand
Burroughs	Research Appliance
Clary	Royson
Computer Measurements	Shepard Labs
Electronic Associates	Soroban Engineering
Datex	Streeter-Amet
Friden	Stromberg Carlson
Hewlett-Packard	Taller & Cooper
International Business Machines	TelAutograph Olivetti
Kleinschmidt	Teletype
Monroe Calculating Machine	Telechrome
Moseley	Underwood
Non-Linear Systems	Veeder-Root
	Victor Adding Machine

Nearly all of these manufacturers of printout equipments will supply data loggers upon request, and hence their names should be added to those in the following list of companies who specialize in logging systems.

The following survey establishes the great variety and types of available loggers. Most fall into two basic categories—(1) loggers for test data and (2) loggers for operational or process data. The former are designed to accept a large amount of data in a short time, and feature high-speed (100-1000 samples per second and higher) scanning, digital conversion, and logging, usually on tape. The latter feature low-speed logging and scanning (1-10 channels per second), but can include many auxiliary aids to operating personnel such as alarm limit monitoring and trend recording of selected variables.

Fig. 1 shows a block diagram of a simple type of logger designed for process or test application. Fig. 2 shows more advanced types of loggers for process application, which can have alarm monitors and trend

Fig. 1. Simple data logging system for process or test application.

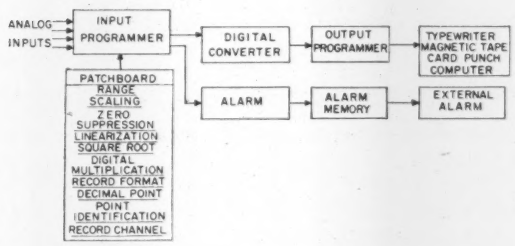

Fig. 2. Advanced logger.

recording. Fig. 3 shows an advanced data telemetering system for test purposes. The simpler systems cost from $5000 to $50,000; the advanced systems from $50,000 to $500,000. The following survey of equipments shows the many modifications of these basic systems. Many are tailored to specific fields, such as loggers for tank fields.

The basic elements of the logger are (1) scanner, (2) digitizer, and (3) printer. Each of these has been surveyed in previous issues.* This survey of loggers thus shows how the components previously discussed are formed into systems for logging data. A future survey of memory devices and control computers will culminate this 4-year series on basic digital techniques.

The following companies are included in this survey:

Austin Electronics	Gilmore Industries
Bailey-Metrotype	Hagan-Kybernetes
Beckman	Hanson-Gorrill-Brian
Bristol	Honeywell
BJ Electronics	International Business Machines
Consolidated Electrodynamics	Kearfott
Cubic Corp.	Leeds & Northrup
Datex-Giannini	Librascope
Daystrom Systems	Monroe Calculating
Electro Instruments	Non-Linear Systems
Epsco	Panellit
Fischer & Porter	Potter Instrument
Franklin Electronics	Radiation, Inc.
Friden	Telecomputing Corp.
Garrett Oil Tools	Thermo Electric
General Controls	Vapor Recover Systems

Austin Electronics

Austin offers special-purpose logging systems. The logging systems shown in Fig. 4 were furnished to N.A.S.A. Moffett Field, California, for use with 1′ x 3′ supersonic wind tunnels.

*May, 1959; August, 1958.

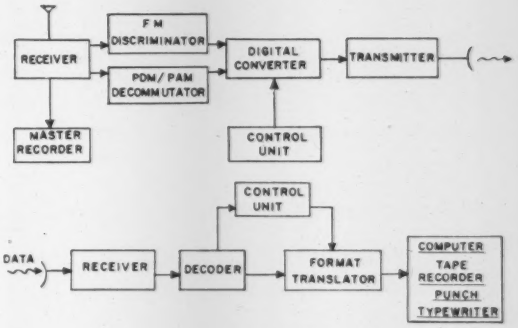

Fig. 3. Data processing system with telemetering link.

Each system provides for sequential sampling and digitizing up to 100 temperature and pressure signals in the ±30 mv range. The digital values are recorded along with a substantial amount of manually inserted data on punched paper tape and typewritten log sheets. Scanning is by electromechanical stepping switch. Digital conversion is by Austin shaft recorder.

Fig. 4. Austin system.

A 30″ x 30″ plotter records digital data points simultaneously.

The systems employ Bristol Dynamasters. Automatic zero suppression nets provide accuracies of better than 1 part in 10,000.

The main console controls recording mode and recording frequency of the three systems and routes the digital data to a remote 1103 computer.

Format program revision and remote transmission facilities are controlled through a substantial switch band and an IBM removable patchboard.

Approximately 35 logging systems of various types have been installed to date, particularly in test-type applications in missile, aircraft and research facilities. These comprise a total of about 1500 channels of logged data.

Bailey Meter

Bailey's Metrotype Information System (Fig. 5) can log numerical values on typed pages, indicate the measurements on numerical lamps, store the information on punched tape, and compare the measurements as they are made against preset high or low limits

for detection or off-normal conditions. These functions are available individually or combined.

Solid-state electronic equipment is used where high speed and high duty cycle demand it. Relays are operated by separate control circuits, thus obtaining dependability which is independent of individual component characteristics. Each system incorporates a calibration check.

The system can accept any a-c or d-c voltage, pulses or contact closure, and can be furnished with pneumatic-electric converters for use with pneumatic systems. The system can be arranged to provide practically any combination of log formats and/or indicating and alarm functions, and can log 2-, 3-, or 4-digit numbers and positive or negative reading, intermingled.

Sequencing and programming functions are established on patchboards or magnetic drums and can be changed readily. Time interval between periodic logs is adjustable.

Standard scanning-monitoring speeds of from 1 to 5 points per second, and logging speeds up to 1 point per second are available. Higher speed scanning of hundreds of points per second, and logging to 10 points per second (via intermediate punched tape) are available for some types of variables.

Input signal switching is by miniature telephone-type relays, mercury-wetted relays or solid-state switching, depending on application.

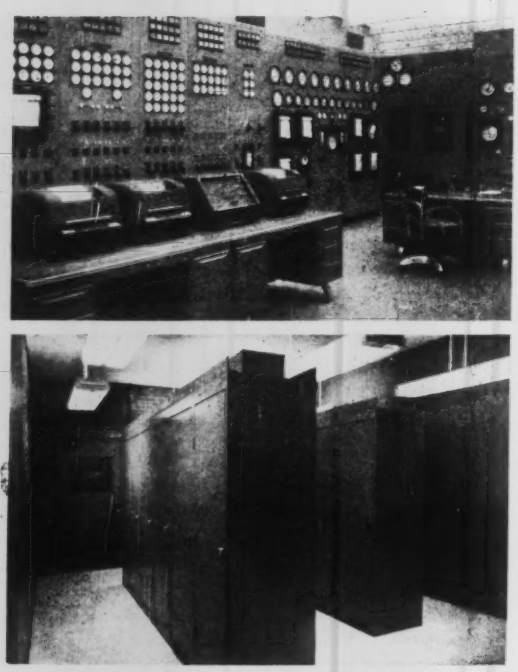

Fig. 5. Bailey Metrotype system.

A separate measuring circuit is used for each class and basic range of input signals to be handled. The measuring units (completely electronic circuitry with no balancing type potentiometers or servomechanisms) convert the input signals to a standardized linear d-c signal of at least 1.0 volt per 1000 digits. Linearizing is done by passive electronic circuits. Selection of the proper measuring circuit for the particular signal involved is made by means of mercury-wetted relays.

Magnetic drum programming is used for more complicated systems such as those where set points are a function of load. The use of magnetic drums provides additional programming possibilities.

An all-electronic null-balance sampling-type circuit converts the standardized voltage from the measuring circuit to a digital signal.

Conversion of the digital signals to Teletype coded output signals necessary to operate the printers is accomplished through a diode matrix without the use of relays or sequencing switches.

Teletype Model 28 Page Printers are the standard printout mechanism, although any type of electric typewriter can be used.

About 8 Bailey Metrotype systems are in operation to date, particularly in the power industry. These comprise about 1200 channels of logged data.

Beckman

The Beckman 123 Data Processing System (Fig. 6) and the earlier 112 (Fig. 7) are programmed on pinboards in advance of operation. Signals are fed directly to the loggers by transducers measuring temperatures, pressures, flow rates, etc. The system scans these signals at the rate of 2 channels per second (5 per second in the 112). Solid-state circuitry is used.

Scanning is by electromechanical switches; analog-to-digital conversion is by conductance adders.

Pinboard programming is used to insert instructions dealing with input range, scaling, linearization, zero-offset, alarm limits, digitizing, and computing. Pinboard instructions also can include recording the time at the beginning of each scanning cycle.

To confirm that the system is following the programming, the operator can visually check the Pro-

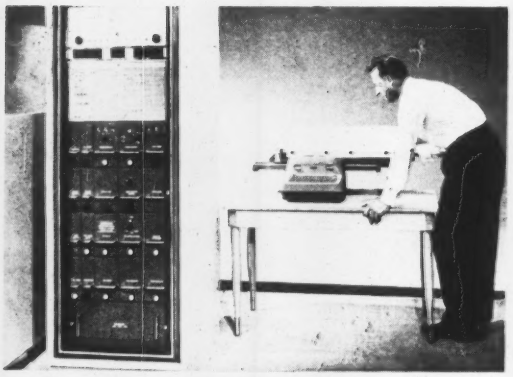

Fig. 6. Beckman 123 data system.

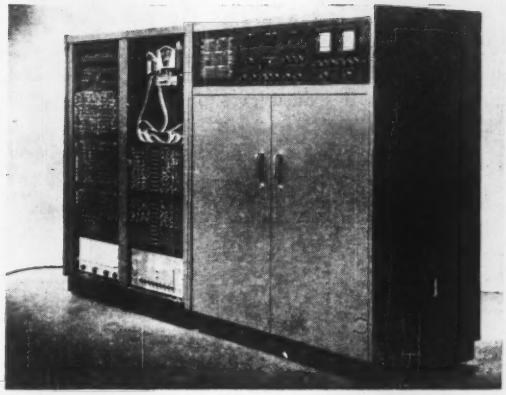

Fig. 7. Beckman 112 System.

gram Summary Board, which shows the operations being performed for each channel as it is scanned.

High accuracy (better than 0.1%) is attained by abandoning ground-return, single-wire lines carrying transducer signals. The ground-loop problem is eliminated by directly connecting the plant measuring elements with ungrounded system input modules through insulated leads.

The basic 123 has 100 channels. The addition of scanning modules—with simple changes in pinboard instructions—quickly adapts the 112 to up to 700 channels.

In addition to scaling, linearizing and zero-offset, the 123 or 112 can perform computations such as maximizing, minimizing, averaging, smoothing, integration, square root, differentation, and some equation solving.

The first 112 system was installed in Dec., 1957 at Philips Chemical Co., Sweeny, Texas. It had 400 channels. Since that time about 15 systems have been installed, for a total of more than 2700 channels, in steel mills, refineries, chemical plants, nuclear reactors, nylon plants, etc.

COMPARISON OF 112 AND 123 SYSTEMS

	112 System	123 System
Scan rate	5/sec	100/min
Program summary board	Yes	No
Totalizing	Yes	No
Scaling	Yes	Yes
Linearizing	Yes	Yes
Square root	Yes	Yes
Averaging	Yes	No
Integration	Yes	No
Smoothing	No	No
Differentiation	No	No
Equation solving	Limited	No
System in operation	15 +	Just introduced
Alarms	High and low Separate alarm typewriter	High or low Alarm and log on same typewriter
Capacity	Up to 700 channels	Usually 100 or 200 channels

Bristol

Bristol offers the Data-Master* Digital Logger designed to log up to 50 process variables. The unit automatically prints a three-digit value with decimal in columns on a log sheet. A simultaneous strip-chart analog record is optional. Printing is continuous, on demand, or at intervals under the control of a timer.

The logger will accept electrical outputs from Bristol's Series 614MIB Differential-Transformer Transmitters for measurement of pressure, flow, differential pressure, etc.; from thermocouples; from resistance thermometer bulbs; or from other sensing elements having a resistance or d-c voltage output proportional to the measured variable. These electrical signals are

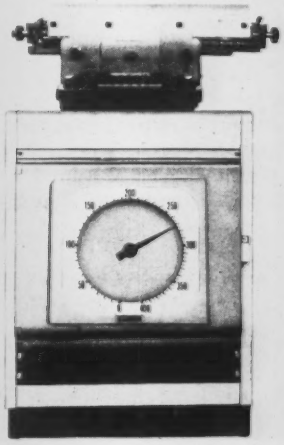

Fig. 8. Bristol Data-Master Type 1.

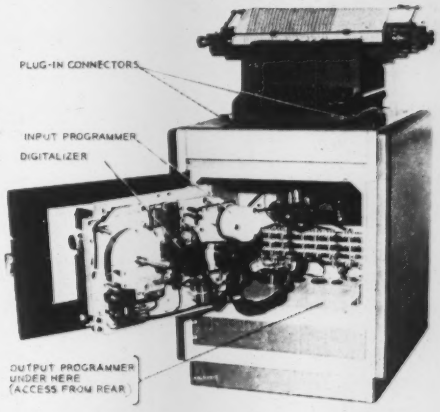

Fig. 9. Bristol Data-master type 2.

programmed directly into a Dynamaster equipped with a digital converter. The emf or differential-transformer signal can be carried several thousand feet, or a Metameter receiver movement driving a linear differential transformer or slidewire can be supplied for greater distances.

The Data-Master Logger is furnished in three basic versions. Type 1 (Fig. 8) uses stepping-relay input

*Data-Master is a registered trade-mark of Hanson-Gorrill-Brian, Inc., Glen Cove, N. Y. The Data-Master system uses the Bristol Dynamaster self balancer as a basic measuring component.

programming and does not include chart-recording. Type 2 (Fig. 9) presents an analog strip-chart record as well as a typewritten digital record, and employs a Dynamaster multiple-mechanism to program inputs. Type 3 is similar to Type 1 but has additional cabinet space and circuitry. This allows more flexible programming, digital time and address printing, a number of separate off-normal alarms with alarm points printed in red, mixed inputs, range-changes, etc.

BJ Electronics

The BJ Electronics* S-100 Automatic Data Handling and Recording System (Fig. 10) is designed to measure and record sequential information from various points during the test of jet, rocket engines, reciprocating engines, etc. The system will measure and process up to 500 test variables at sampling and readout rates to 100 per second.

Pressure measurement is performed by Vibrotron digital pressure transducers and digitizing components to provide pressure measurement from 3 to 10,000 psi. A pressure to be measured is selected by a scanner and routed through an appropriate selector switch to

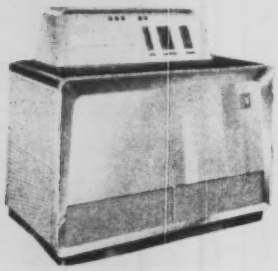

Fig. 10. BJ Electronics S-400 system.

a transducer-bank input manifold. The selected pressure is then presented directly to the maximum-range transducer and, after stabilization, a reading is made and classified to determine the proper measurement transducer. A reading is taken from the measurement transducer and the digital value, linearized and correctly scaled, is stored in the buffer storage register (until requested by the data-recording subsystem).

The thermocouple selectors comprise a bank of stepping switches which transfer the millivolt thermocouple output to a multi-range servo instrument.

Capacity to accept inputs from other measurement instrumentation in the form of millivolt and frequency signals has been incorporated. Frequency instrumentation capacity provides for measuring up to 20 signals.

The outputs also can be stored in a buffer storage register until demanded by the data-recording subsystem. The Data-Recording Subsystem output include tabulations, punched cards and tape, and visual display; provisions for other output media also can be incorporated as required.

BJ data systems have been installed at Rocketdyne Corp. for engine test, at Southern Calif. Cooperative Wind Tunnel, etc.

BJ Electronics, Borg-Warner Corp.

Consolidated Systems Corporation

CSC offers the MicroSADIC (all-solid-state) data acquisition and handling system (Fig. 11). Data comes in through transducers or through FM-PDM

Fig. 11. CSC MicroSADIC.

radio link through telemetering equipment. The MicroSADIC output is usually magnetic tape. It is designed for high-speed data processing, and provides high accuracy, compatibility with all standard computers, reliability and flexibility.

Input scanning is by switches which feed a bank of high-speed transistor switches for 10,000 sample/sec commutating of the inputs (sampling).

The translator (converter) is based on the "doubling" principle. The numbers are shifted serially from a sb register into a bcd register and the content of the bcd register is doubled with each step. A digital value is arrived at in approximately 85 microseconds.

The Time Sequence Control offers three selections —(1) one sampling period only, (2) repeated sampling periods, (3) continuous operation at maximum sampling rate.

Data is commonly stored in the form of pulses on a magnetic tape, which can be any of 16 formats. The magnetic pulses are identical; their location on the tape determines the content of the message. Therefore, a strict order of writing pulses on the magnetic tape must be determined. This order is called the "format" and is different for different computers.

A "performance analyzer" injects an analog voltage equivalent to a given digital signal (say 985 counts); any error in any channel stops the machine and indicates where the error exists.

More than 500 SADIC, milliSADIC, and microSADIC data systems are in operation, particularly in reducing telemetery flight data and processing data from wind tunnels, nuclear reactors, and jet-engine and thermal-structure test facilities.

Cubic Corp.

Cubic provides data logging by combining their input scanner and digital voltmeter with an output printer. (Fig. 12).

A controlling Master Scanner and Auxiliary Scanners can sample as many as 1000 input channels. The system permits scanning intermixed a-c and d-c voltages, resistances or low-level d-c voltages in conjunc-

tion with a Pre-Amplifier, Model PA-1. Channel can be selected by remote command, by manual control or by automatic sequencing from a pre-set start channel to a pre-set stop channel. An override timer commands the scanner to advance to the next channel if reading or balance has not been achieved within 15 seconds.

The Auxiliary Scanner Unit accepts up to 100 one-wire inputs (or 50 2-wire inputs or 20 4- or 5-wire inputs), and individual channels are selected as programmed by the Master Scanner. The outputs of the Scanners can be fed into the Cubic Pre-Amplifier, the a-c converter, a Scale-Factor Attenuator or directly into the Voltmeter. Output also can be provided for limit testers and printers.

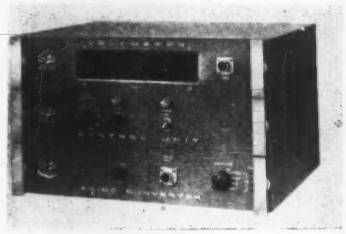

Fig. 12. Cubic data system.

Outputs are provided for printers or remote indicators and optional configurations, such as external reference and ratiometer use.

Printers can be (1) parallel having an input for each character in each column, (2) serial, to sequence symbols and digital outputs to operate typewriters and card punches, (3) scanning, where a commutator is synchronized with the motion of a print wheel, and (4) coding used with printers such as Flexowriters, which use special digital codes.

Datex

Datex offers logging systems based on their shaft-position encoder. Typical is the Datex temperature recording system (Fig. 13) designed to measure and record up to 75 thermocouple inputs.

The system consists of an input scanner, self-balancing potentiometers, shaft encoders, encoder selector, control chassis, programmer, digital clock and an electric typewriter. Scanning rate is 3 seconds per data point; this scan cycle duration is 225 seconds. The scan cycle can be initiated manually, or automatically ½ to 3 minutes after completion of the last logging cycle. The system is accurate to ±1°F in the two lower ranges and ±5°F in the 0-1200°F range. Readout format is 2 decimal digits of identification followed by 4 decimal digits of temperature.

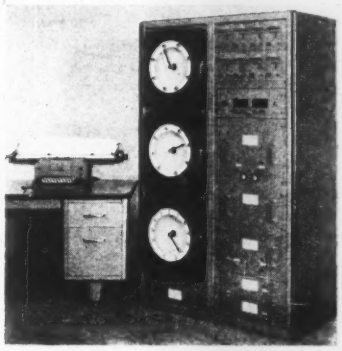

Fig. 13. Datex temperature recorder system.

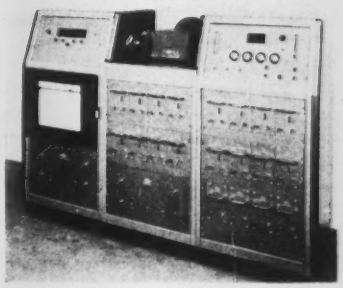

Fig. 14. Datex 200-point logging system designed for testing of vacuum tubes.

Datex-installed recording and control systems include wind-tunnel instrumentation, steel mill control, and radio and radar telescope (missile-tracking) indicating and control.

Daystrom Systems

Daystrom Systems offers both logging and control computer systems, (the latter will be described in a following issue).

Daystrom's recently developed TPR (Tape Programmed Raw) Data Scanning System is designed to link plant or test facilities to remote, already established, computer facilities through the use of standard telephone communication services. This equipment is designed to improve the economic feasibility of logging and data reduction in conjunction with process studies and experimental work where investigations are intermittent or of limited duration.

Fig. 15. Daystrom 2000-point system, recently expanded to 3,200 points.

Programming is accomplished by high-speed endless-loop mylar tape. The tape addresses the input channels in required order and establishes amplifier scaling ranges.

A new second-harmonic-type amplifier features five scale ranges, high common mode noise rejection, open circuit detection, 1/10% accuracy at the 99% confidence level, and long-term low drift at forty conversions per second.

Construction is entirely solid-state. Input switching is accomplished by mercury-wetted relays, with crossbar switching available as an alternate for cost reduction. The equipment handles from 100 to 6000 input channels. Full format and parity checking is incorpo-

rated and the equipment can be stopped and single-stepped from the control panel where any number in the system may be read out visually.

A 2,000-point system typical of this type has been delivered by Daystrom to Atomic Energy Commission's National Reactor Testing Station in Idaho (Fig. 15). Daystrom logging systems have also found application in the electric power, steam generating, and chemical process fields. These systems are presently monitoring 2,400 channels of process and test data in the field. Another five systems (2,000 channels) are scheduled for operation in near future.

Years of field operating experience permit Daystrom to guarantee better than 99% operational availability for on-line data logging and data reduction systems.

Electro Instruments

Electro Instruments offers special-purpose loggers built around the E-I digital voltmeter. Fig. 16 shows a system with a 100-channel scanner; it can digitize

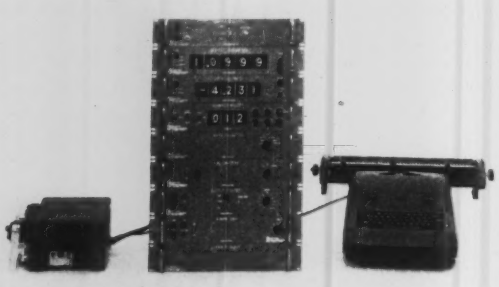

Fig. 16. Electro 100-channel logger.

resistance, d-c voltage, a-c voltage and dc-/d-c voltage ratio analogs. Digital equivalents of these analogs are recorded on an IBM typewriter for a "quick look" and on punched paper tape for additional data reduction by a digital computer.

Scanners are available to accommodate up to 10,000 inputs. Logging rate averages 30 per minute.

About 200 E-I logging systems have been installed to date, comprising 50,000 channels of data.

Epsco

Epsco offers special-purpose logging systems based on its Datrac and Transicon electronic high-speed analog-to-digital converters.

Fig. 17 shows a Transicon alarm limit monitor, which can monitor from 1 to several thousand variables.

Test sequence instructions and high-and low-limit boundaries are programmed (on paper tape or magnetic tape) and read into the programmer unit. The programmer (1) sequences the input analog voltage signals, (2) makes appropriate scale-factor adjustments on input amplifiers, (3) performs other required conditioning operations, and (4) sends the conditioned analog voltage signals to the monitor. (Conditioning refers to scaling, applying linearization, zero suppression, and square rooting required for the output analog signal of orifice-type flow meters. Another conditioning operation called span control is the expansion of only one interesting segment of a complete analog voltage range.)

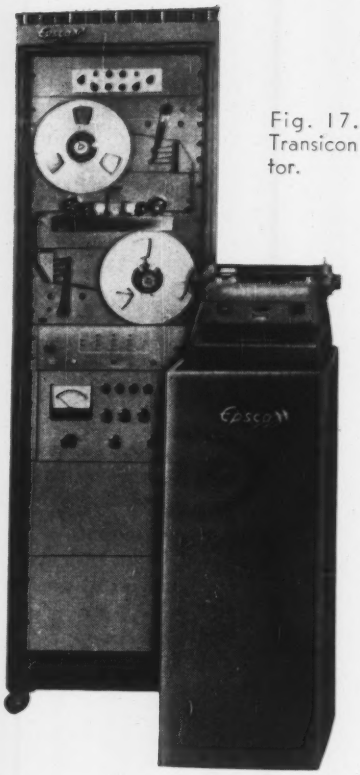

Fig. 17. Epsco Transicon monitor.

A numerical display or printout can be provided the system operator. This information can identify the location of the fault, give corrective instruction, read out expected and actual value, etc. The numerical identification data can be stored on tape and printed out when there is an alarm situation.

To provide a permanent record of the monitoring operation, output recording or printing equipment can be employed. This equipment can be a magnetic tape recorder, a paper tape punch, a card punch, a high-speed in-line printer, or an automatic typewriter.

Fig. 18 shows a petro-chemical data acquisition system which converts multichannel analog inputs into coded decimal for on punched paper tape format for use in a Datatron computer. The digital conversion rate is 40 kc max; conversion accuracy is 0.1% full scale.

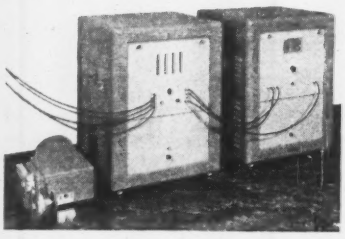

Fig. 18. Epsco petro-chemical system.

Fig. 19 shows a large-scale structure-analysis data-reduction system designed for the Army. Specification include:

Inputs—400 low-level strain-gage signals; 120 thermocouple signals.
Switching rate: 1000 samples/sec
System accuracy: 0.4% full scale, ½ of least significant digit
Output: magnetic tape in computer format.

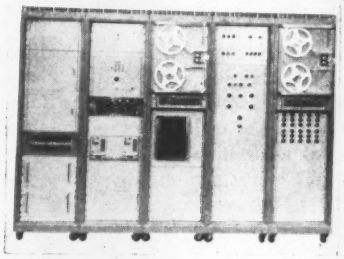

Fig. 19. Epsco large-scale system.

Approximately 50 logging systems of various types have been installed to date, particularly in the aircraft, missile and chemical industries, and in scientific laboratories. These comprise a total of about 7000 channels of logged data. Largest Epsco system to date has 600 channels.

Fischer & Porter

Series 1200

F&P's Series 1200 industrial data loggers and alarm scanner (Fig. 20) accepts any combination of either up to 200 or 2000 inputs (depending on the scanning

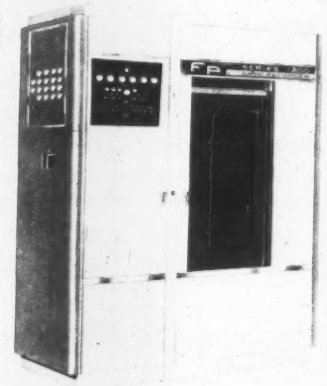

Fig. 20. F&P 1200 data logger.

method used) makes conversions to d-c voltages, performs zero offset, scaling, and characterizing of nonlinear inputs. Inputs may be dc, ac, variable frequency, or pneumatic.

Two scanning systems are available. One uses individual point relays, with individual alarm-limit set points and ranging adjustments, to provide maximum reliability and flexibility. The other provides ten times the input capacity by means of ten-point stepping switches. All points on a stepping switch share the same alarm limits and the same programs. Scan rate is 1 or 2 points/second.

Analog-to-digital conversion is electronic. The transistorized analog-to-digital converter (TAD) can perform 6000 conversions per second.

Pinboard programming establishes sequence in which inputs will be measured and read out, and permits readout of any input any number of times per logging cycle. It also selects any input for visual readout on a digital in-line display.

Between and during logging cycles, which occur on demand or at preset intervals, inputs are continuously scanned and compared against limit set points. If desired, detection of an off-normal condition can result in a complete printing of all points with alarmed points in red. As an alternative, only the points detected as abnormal will be printed, with suitable identification preceding the reading.

Model 1542

The Fischer & Porter Model 1542 analog-to-digital recorder (Fig. 21) is a low-priced battery-operated

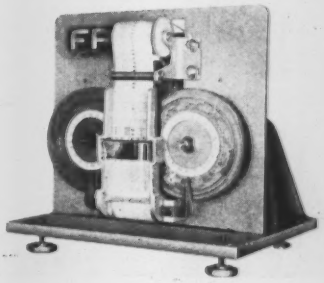

Fig. 21. F&P 1542 data logger.

device that measures, converts, and records analog values in digital binary-decimal punched-tape form. Simultaneously, it supplies a parallel binary-decimal output in electrical form by means of sixteen contact closures, each of which matches a position on the digital tape record. Also, calibrated discs can be read directly. Thus, digital binary-decimal readout is in three basic forms: direct visual readout (calibrated discs); electrical (contact closures); and mechanical (punched tape).

The ADR measures analog values as shaft position. One rotation of the input shaft equals 100 counts; each 3.6° of rotation represents a discrete digital value.

The two code discs have raised portions on their front surfaces which represent digital values in binary-decimal code. Each 1/100th rotation of the input shaft sets up a unique configuration representing a discrete binary-decimal value of that particular shaft position.

Pressure Readout

F&P also offers a Multiple Pressure Readout System which measures many different pressures a single point at a time. Large numbers of pneumatic signals are simultaneously converted to digital values with an accuracy of better than one part in 2000 by using a single, accurate *Press I-Cell* transducer.

The operation is as follows:

1. Operator causes all system valves to close at beginning of measuring cycle by pressing button, trapping pressure "samples" in comparators.
2. System pressure is increased in increments;

Press-I-Cell automatically registers system pressure as it is increased by uniform increments.

3. When system pressure equals input pressure at any comparator, a contact is broken and Press-I-Cell reading is automatically read into ferrite core memory.

4. System pressures continue to increase by regular increments until all input pressures are read into memory. All pressures are thus memorized in one sweep cycle.

F&P also offers the Simultaneous Temperature Alarm Readout (STAR) with 100 points, which can work into MOR Millisecond Operations Recorder (Fig. 22) for digital printout or tape punch of any

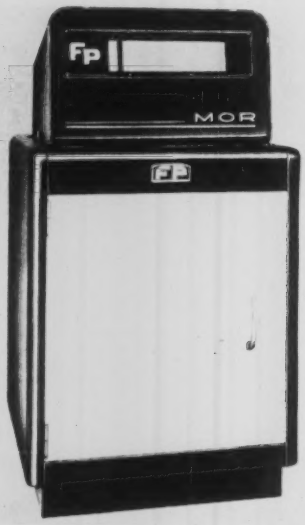

Fig. 22. F & P MOR system.

channel that exceeds preset limits. The MOR is also basically a monitor.

F&P loggers have been installed in the chemical, petrochemical, test facilities, electric power, pulp and paper, nuclear, steel and municipal industries. About 37 installations now are logging or monitoring approximately 6800 channels.

Franklin Electronics

Communications & Control Division of Franklin Electronics offers a new economy 20-channel logging system "Candu-1" (Fig. 23). The digital output can be

Fig. 23. Franklin CANDU-I system.

used to actuate printers, tape punch, etc.

Input is fully differential and isolated. Low-level signals can be transmitted hundreds of feet without pick-up or noise, permitting use with low-level strain gages and thermocouples.

Accuracy is better than 0.25%, including drift, gain and linearity stability. Input impedance is better than 500,000 ohms.

Scanning speed is 4 steps per second.

Output includes (1) visual display on Nixie tubes and (2) 1-2-2-4 binary coded signals, polarity, decimal position and channel identification. Basic package can accommodate to 200 channels in units of 20.

Friden

Friden offers logging systems which include their motorized tape reader and Flexowriter (typewriter) Programmatic. The combination enables the Flexowriter to read selectively from two originating tapes or cards under the control of codes punched into the tape. By-product tapes as well as hard copy can be logged at a rate of 572 codes per minute.

Garrett Oil Tools

Garett offers a data system for well field "lease automation" (Fig. 24). The system obtains information

Fig. 24. Garrett lease automation system.

on each individual well, such as how much oil, gas and water are being produced, conditions in the well, pressure, the well's allowable and other data. Simultaneously, this information is recorded on permanent IBM file cards for reservoir studies.

General Controls

General Controls offers special-purpose loggers for oil-field use (Fig. 25). Basic systems feature remote

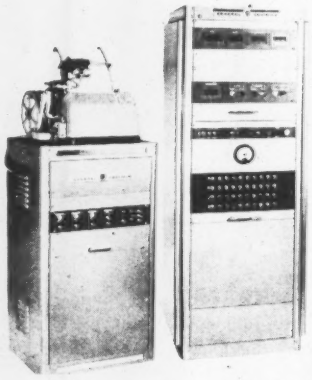

Fig. 25. General Controls oil-field system.

interrogation and telemetering assiciated with oil-field operation. Switch scanning is used: the input is usually digital data taken from counters. Transmission is at a rate of 60 words per minute Teletype. Punch tape and printed outputs are available.

Each well in a system also can be remotely switched into the flow measuring system for proving the flow rate of the well. Basic units comprise (1) a well test and remote data-accumulation and transmission controller, (2) a data receiving station and (3) supervisory control. System can also report alarm conditions, and teletype tape can be used in standard accounting equipment to compute reservoir engineering data and make automatic payment of royalty checks.

Gilmore Industries

Gilmore offers data loggers for pressure, temperature, strain, displacement, etc., with speeds to 20 points per second, up to 100-channel modules, and accuracy to ±0.1%.

Fig. 26 shows the Model 167, a 48-point system with

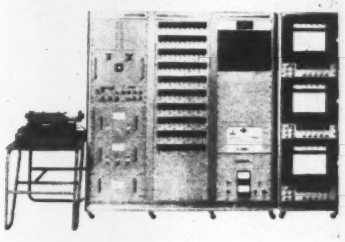

Fig. 26. Gilmore Model 167.

multi-range selection, interlocked switching to prevent loss of synchronization, strip-chart potentiometer recorders, plus typewritten logged data at a rate of 2 seconds per point. Accuracy is ¼% full scale. High-low alarm monitoring is available as accessory.

Other options include zero control and logging speeds of 1 and 4 seconds per channel.

Ranges can be any standard millivolt or thermocouple range with automatic cold-junction reference compensation, linear or non-linear to suit the thermocouple circuit.

To date, about 10 installations comprise about 2000 channels of logged data.

Hagan-Kybernetes

The Kybernetes Series 2000 data system (Fig. 27) features solid-state electronics, pinboard programming, electric scanning of inputs at a rate of 4 per second, and sweep-time type analog-to-digital conversion. Transducer and thermocouple leads are brought into the system to two terminals on a patchboard located at the rear of the input switching unit. Additional contact levels on the input relays connect into the pinboard programming system to select the proper scale factor, linearization, zero suppression, alarm set points, square root, multiplication, division and other functions for each input.

Individual, hermetically-sealed, plug-in relays for each input are arranged in horizontal and vertical rows in the form of a matrix, and are impulsed by an electronic master drive unit. *This unique input selection technique allows random access to any point even while alarm scanning other points.* Thus, alarm scanning continues at 3 points per second even when logging, trend logging, and continuous viewing of a point. Normal alarm scanning when not logging is 4 points per second.

Substantial a-c or d-c circulating currents on the signal lines due to differences in ground potential between the grounded transducer and the data system required special consideration. Kybernetes meets this problem through sequential chopping of the analog voltage onto a capacitor. This permits transfer of these signals to the data system without creating a continuous path through which a-c or d-c currents can flow, and without any measurable loss of signal.

A patented chopper-type d-c amplifier has long-term drift of less than 30 microvolts; noise less than 5 microvolts; input impedance is in excess of 10 megohms.

Output information can be transmitted to typewriters, adding-machine-type printers, tape punches, card punches, and magnetic tape systems. Typewriter carriage lengths permit a writing line of approximately 27 inches, so that up to 90 three-digit variables can be recorded per line. Where the variables to be logged exceed 90, additional typewriters are recommended.

Fig. 27. Hagan Kybernetes system.

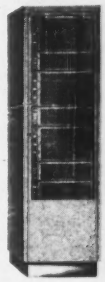

Fig. 28. Patch panel.

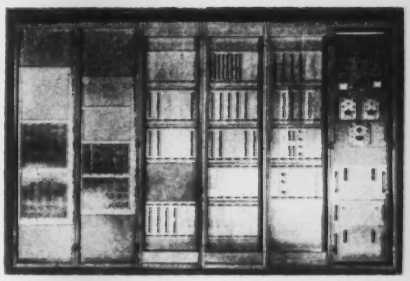

Fig. 29. Main Console.

When off-normal alarm or trend logging is required, the data is usually recorded on a separate printer. The standard print-out speed is one point per second, including the space between variables.

Pinboard programming is a feature of the system. Simply by the insertion of pins into a pre-wired board, the desired operational characteristics of full scale ranging, zero suppression, trend logging, alarm set points, function programming of such items as linearization, square root extraction, amplifier gain, computations, and number of digits logged can be selected.

Linearization is ±1°F over the full range of the thermocouple type. Over-all accuracy is ±0.1% of full scale.

Hagan-Kybernetes systems are now in operation in about 22 installations, particularly petrochemicals plants, refineries, steel mills, power stations and boiler houses. These installations total about 3640 channels.

Logger survey will be concluded in December issue.

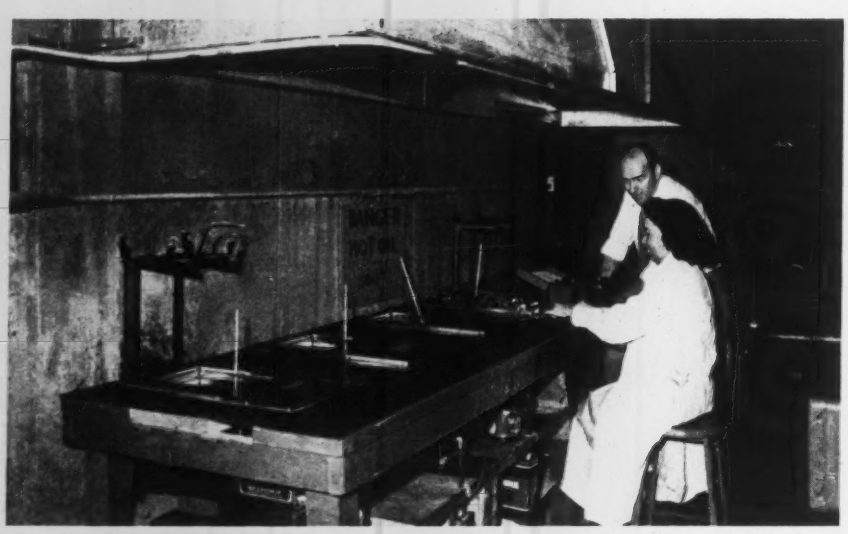

FIG. 1. TYPICAL INDUSTRIAL calibration bath installation. Each bath is maintained at one calibration temperature.

How Accurate

ALVIN B. KAUFMAN
Litton Industries
and
WILLIAM E. DREES
Arnoux Corp.

THE ACCURACY with which temperature transducers are calibrated depends on the instruments and techniques employed. The proper use of various types of calibration instruments such as thermometers, bridges, temperature baths and allied equipment requires careful technique and attention to detail.

Thermometers

Thermometers selected for low- and medium-temperature calibrations should be examined for readability, stability, and accuracy by study of ASTM and manufacturer's specifications. In order to maintain maximum accuracy they should be mounted rigidly to the exact immersion depths required and subjected to slowly varying temperatures to prevent thermal response error.

Many mercury-in-glass thermometers require immersion to either a specified depth or to the readout temperature (total immersion type). In the latter type, accurate readout is difficult but the accuracy of the total immersion thermometer can be maintained even when used partially immersed by *stem correction*, without impairing ease of readout. Tables 1 and 2 indicate the accuracies and emergent-stem corrections for a sampling of calibration-type thermometers in the −90°F to +500°F temperature range. Equations and nomographs for stem correction can be obtained in the literature.[1] Table 1 applies to precision (high-accuracy) types; table 2 to standard types. The standard types of calibration thermometers can be obtained at a cost somewhat less than $50,* whereas the precision types cost four times as much.[5] The accuracy desired (and cost) establishes which thermometers are used.

Thermocouples

Thermocouples should not be used for measurement of calibration temperatures in the low- and medium-

TABLE 1—TYPICAL PRECISION CALIBRATION THERMOMETERS[3]: ACCURACY AND STEM EMERGENT CORRECTION

Calibration Point (°F)	ASTM #	Range (°F)	Imm. Point[1]	°F Accuracy[2]	Stem Correction (°F)
−90	6F	−112, −70	3" depth	1.0	0.0
−65	74F	−67.5, −62.5	−62.5°F	0.2	0.015
0	72F	−2.5-2.5	−2°F	0.2	0.001
77	17F	66-80	70°F	0.2	0.05
100	28F	97.5-102.5	97.5°F	0.2	0.02
200	66F	165-220	190°F	0.2	0.175
212	30F	207.5-212.5	210°F	0.2	0.035
300	78F	295-315	295°F	0.5	0.125
400	80F	395-415	395°F	0.5	0.180
500	69F	385-580	490°F	1.0	0.45

1. Depth to which thermometer immersion in the calibration media shall be made.
2. Accuracy at any point on the scale. Note: Scale divisions same.
3. See reference 6 for additional thermometer specifications.

*Total price for all the thermometers listed in Table 2.

Are Your Temperature Transducer Calibrations?

Technique for accurate temperature transducer calibration includes consideration of thermometer immersion, thermocouple type, bath type, bridge factors and reference temperatures.

temperature range as their error may be an excessive percentage of the measured value. The thermocouple has a possible maximum error of 4°F or more in the range of −100°F to +530°F; therefore, the use of a thermometer with its higher accuracy is desirable up to about 500°F.

Baths and Test Chambers

The use of oil and water baths (Fig. 1) is preferable over air environmental test chambers because of lower temperature gradients and closer accuracy of temperature control in the temperature range of +32°F to +500°F. Where environmental test cham-

TABLE 2—TYPICAL STANDARD CALIBRATION THERMOMETERS*: ACCURACY AND STEM EMERGENCE CORRECTION

Calibration Point (°F)	ASTM#	Range (°F)	Imm. Point	°F Accuracy	Stem Correction (°F)
−90	6F	−112, −70	3"	1	0.0
−65	6F	−112, −70	3"	1	0.015
0	6F	−112, −70	3"	1	0.001
77	17F	66-80	70°F	0.2	0.05
100	9F	50-230	95°F	1	0.045
200	9F	50-230	190°F	1	0.195
212	9F	50-230	210°F	1	0.035
300	1F	0-300	295°F	1	0.125
400	2F	20-580	395°F	2	0.180
500	2F	20-580	490°F	2	0.45

* Notes per Table I apply here.

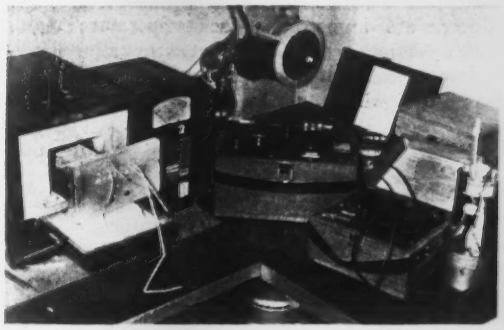

FIG. 2. TYPICAL HIGH-TEMPERATURE calibration furnace with Wheatstone bridge and potentiometer. The Dewar (thermos) at right is used for a 32°F calibration check point. Insulated furnace box is shown withdrawn partially.

FIG. 3. TWO HIGH-TEMPERATURE transducers are shown with attached thermocouples in insulated furnace box, which shields elements from direct radiation from furnace elements.

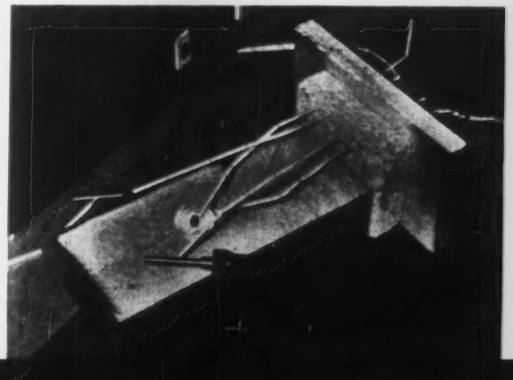

TABLE 3—TYPICAL CALIBRATION-SYSTEM ERROR EVALUATION

Temp. (°F)	Bath Reg.	Bath Gradient	TC or Thermometer	Readout Inst. Error[1]	Max Error (°F)	Probable Error (°F)
−320	Constant	None	None	±.1%=8Ω=.16°F	±0.16	±0.16
−302	Constant	None	None	±.1%=8.3Ω=.116°F	±0.116	±0.116
−65	±2°F	±3°F	±1°F (Any Point)	±.1%=14.2Ω=.285°F	±6.285	±1.88
−50	±2°F	±3°F	±1°F (Any Point)	±.1%=15Ω=.30°F	±6.30	±1.88
0	±2°F	±3°F	±1°F (Any Point)	±.1%=17Ω=.34°F	±6.34	±1.88
32	Constant	None	None	±.1%=18Ω=.36°F	±0.36	±0.36
77	±.45°F	±.25°F	±.3°F (Any Point)	±.1%=20Ω=.4°F	±1.35	± .359
100	±2°F	±3°F	±1°F (Any Point)	±.1%=20Ω=.40°F	±6.4	±1.88
200	±.45°F	±.50°F	±1°F (Any Point)	±.1%=26Ω=.528°F	±2.48	± .658
300	±.45°F	±.50°F	±2°F (Any Point)	±.1%=32Ω=.64°F	±3.59	±1.10
400	±.45°F	±.50°F	±2°F (Any Point)	±.1%=38Ω=.76°F	±3.71	±1.12
500	±.45°F	±.50°F	±2°F (Any Point)	±.1%=43Ω=.86°F	±3.81	±1.14
600	NA[4]	NA[4]	±¾%=4.5°F	±.1%=2.16Ω=1.8°F	±6.3	±3.43
800	NA	NA	±¾%=6°F	±.1%=2.34Ω=±1.8°F	±7.8	±4.26
1000	NA	NA	±¾%=±7.5°F	±.1%=2.49Ω=2°F	±9.6	±5.48
1100	NA	NA	±¾%=±8.25°F	±.1%=2.56Ω=±2.1°F	±10.35	±6.00
1200	NA	NA	±¾%=±9°F	±.1%=2.6Ω=±2.17°F	±11.17	±6.54
1300	NA	NA	±¾%=±9.75°F	±.1%=2.7Ω=±2.2°F	±11.95	±7.06
1400	NA	NA	±¾%=10.5°F	±.1%=2.8Ω=±2.3°F	±12.8	±7.59
1500	NA	NA	±¾%=±11.25°F	±.1%=2.86=±2.4°F	±13.65	±8.14
1600	NA	NA	±¾%=±12°F	±.1%=2.90=±2.4°F	±14.4	±8.65

[1] LN5305 0.1% accuracy
[2] Ice bath
[3] See text
[4] NA=Not applicable, because furnace rather than bath is used.

bers are used, it is necessary to mount the transducers on a non-interference basis in regard to the air flow in order to minimize self-inflicted gradient errors. Also, careful placement of chamber temperature measuring instruments is important due to the gradients of the chamber itself.

Where *oil and water baths* are used and the transducers are immersed, close temperature regulation can be maintained and gradient errors minimized. Also a large number of transducers can be immersed at the same time without causing additional gradient errors.

Calculated Tolerances

In order to determine the accuracy of the temperature transducer calibration, it is necessary to calculate the tolerances of the calibration equipment. Maximum error is the sum of the tolerances (in degrees F or C) of all instruments involved, plus the gradient error of the bath or test chamber.

Probable rms error (X) is the square root of the squares of all tolerances divided by the number of terms. If there are four sources of error, A, B, C, and D:

$$X = \sqrt{(A^2 + B^2 + C^2 + D^2)/4}$$

Table 3 illustrates this formula as applied to a 20,000-ohm wire-wound resistance-thermometer transducer, up to 500°F, and a 4000-ohm transducer above that temperature. This table shows the several errors in calibration of the resistance thermometer with a bath, tc, or thermometer to read bath temperature, using a bridge to read the resistance thermometer.

Thermometer emergent-stem correction has been left out in Table 3 because of its insignificance in comparison with the over-all calibration error. Bath or media regulation is considered an error because of the possibility that the thermal time-constants of the temperature-measuring device and temperature transducer may be such that adequate correction for the variation in temperature is not accomplished. Media temperature gradient can be eliminated as an error if each transducer temperature is measured individually, and if group calibrations are not performed (or multiple temperature instrumentation employed).

Bridge Factors

In calibration tests which require the use of a resistance bridge, it is necessary to convert the bridge resistance error (in ohms) to degrees F or C. This is accomplished by multiplying the probe resistance at any given temperature point by the bridge accuracy tolerance. This will give the error in resistance. The resistance error then can be transposed into °F or °C by dividing the resistance error by the ohms-per-degree coefficient of the probe at that temperature.

Even though the error has been calculated using a 20,000-ohm Balco wire probe in Table 3, the error in °F of the readout instrument will be the same for Balco wire probes of any resistance because probes manufactured with the same resistance material will have proportionally the same dR/°F, excluding those which have series and/or shunt fixed padding or shaping resistors. For example a 20,000-ohm (resistance at 77°F) Balco wire probe has 32,000-ohms resistance at 300°F. When measured on the L&N 5305 bridge, an error of 32 ohms is possible. This probe has a dR/°F of 50 ohms. Therefore, the error is 0.64°F. Similarly, a Balco wire probe with 4000-ohm resistance at 77°F has a resistance of 6400-ohms at 300°F. When used with the L&N 5305 an error of 6.4 ohms is incurred. This probe has a dR/°F of 10 ohms. Therefore the error would again be 0.64°F, the same as for the 20,000-ohm probe.

When making the actual calibration, extreme care should be taken to prevent excessive I^2R self heating within the transducer. Bridge excitation voltages should be as low as possible in order to minimize I^2R effects because errors caused by this heating can amount to several degrees. Transducer excitation, however, should be compatible with its operational use, but where the calibration media is not equivalent to the operational heat sink (such as a surface-mounting probe designed for use on aluminum) low excitation should be employed to limit I^2R heating.

Reference Temperatures

Calibration tests at 32°F can be conducted easily with a bath of chopped ice and water. The use of a 32°F reference ice bath has become more and more accepted as a standard through-out the missile and airframe industry due to its high accuracy as a temperature reference[2]. The ice-water equilibrium temperature is essentially independent of barometric pressure. The transducer need only be submerged into the ice reference and a resistance readout made. A well-charged thermos flask will retain 32°F temperature for a considerable length of time.

Triple-point ice bath vs standard ice bath technique imposes a maximum error of approximately 0.01°C with barometric range between 0 and 80,000 feet. This is negligible for calibration to missile and industrial requirements. However, for precise laboratory research it should not be ignored.

Calibration at the 212°F boiling point of water is not recommended unless the water temperature is monitored, because the boiling point of water varies substantially with variation in altitude or absolute pressure[2] and is affected by equipment configuration. For example, partial closure of the boiling water cannister lid can result in increased vapor pressure, with an increase in water temperature.

Liquid argon and liquid nitrogen can supply calibration temperatures of −302.4°F and −320.4°F; all that is needed is an open-mouth thermos flask (Dewar) and a resistance readout instrument (bridge). The use of liquid argon (A) for −302.4°F and liquid nitrogen (N_2) for −320.4°F calibrations eliminates the requirement of temperature regulation; gradient errors also are negligible. The temperatures, however, are subject to variation by barometric pressure. The accuracy of the temperatures at sea level is about 0.2°F, without pressure correction[3]. The probe is simply placed into the argon or nitrogen and, after stabilization, is read out on the resistance bridge.

Liquid oxygen (O_2) at −297°F is not recommended as general laboratory calibration media because of the hazards involved.

High-Temperature Calibration

Calibration of high-temperature probes is similar to that of the low- and medium-temperature types, but furnaces and thermocouples are used rather than baths and thermometers.

Furnaces are used most commonly for calibrations above 500°F. Liquid baths of metallic or salt agents are sometimes used. However, these are highly conductive or corrosive and are not adaptable for calibration of all types of probes. Therefore, furnaces with air atmospheres are more common. Fig. 2 shows such a furnace.

Because of the high temperatures, furnace temperatures are read directly by a thermocouple attached to the transducer. Even though a chromel/alumel thermocouple has a 4°F or more error in the range of −100 to +530°F, it has only a ¾% error[4] at any point in the range of +530° to +2300°F.

The calculation of the maximum and probable error of the calibration equipment is the same as that for lower ranges.

Technique

In high-temperature-probe calibration the probes should be brought to the desired temperatures slowly. This prevents excessive thermal shock and allows the probe temperatures to stabilize before the reading is taken. A chromel/alumel thermocouple should be attached to each probe under test to measure its temperature with a direct-readout potentiometer. Several probes can be calibrated simultaneously in the furnace; they are placed in an insulated box (Fig. 3) to eliminate gradient and radiation errors. The probe leads should be connected to a switch box. An external battery is selected for the resistance bridge to give proper excitation without causing excessive I^2R heating. When the probes have reached the desired temperature, as indicated by the thermocouple attached to them, the resistance readout is made by switching from one probe to another.

The furnace temperature is usually adjusted by a variable a-c line voltage supplied by a variable transformer.

Chromel/alumel thermocouples are used rather than iron-constantan because of their better stability and higher temperature range. Platinum/rhodium-platinum thermocouples should be used where higher temperature range and accuracy are needed. The high cost of this thermocouple may not permit its use as a standard at ranges where chromel/alumel can be used.

The reader may note that in Table 3 the high-temperature calibration does not include the accuracy of the thermocouple potentiometer used. The potentiometer used by the authors had such an insignificant error that it was not considered. However, the reader should be aware of this factor and not dismiss consideration of the potentiometer without examination.

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2. A. B. Kaufman, "How Accurate are your Temperature Reference Baths?" *Instruments and Automation*, March, 1955.

3. Tables of Thermal Properties of Gases, National Bureau of Standards Circular #564, pages 131, 360.

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Digital Actuators

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Ferguson, Hille & Associates, Inc.

A variety of digital actuators is now available for control use with digital systems.

THE GROWING IMPORTANCE of digital techniques for computation and control has led to the introduction of a complete line of digital actuators. These actuators can be operated directly from digital computers, digital-type remote control stations, or programmers.

Accuracy in all cases is a function of the number of bits or control element stations used in the actuator. A 7-station unit has an accuracy of 1 part in 2^7 or 128; an 8-station unit an accuracy of 1 part in 256; 9-stations, 1 part in 512; 10 stations, 1 part in 1024.

Fig. 1 shows a *digital linear positioner*, comprising cylinders in series; the piston of each cylinder is attached to the cylinder head of the next unit. Positioners are available with strokes from 2″ to 120″ (1/16″ accuracy). Strokes are added and the output shaft is moved a distance equal to the sum of the strokes of each individual piston. The individual piston stroke distances increase in binary progression—that is, if piston 1 has a stroke of 1″, piston 2 has a stroke of 2″, piston 3 has 4″, and piston 4 has 8″, etc. Each piston is either extended completely or retracted. Solenoids can be used for light duty.

Fig. 2 shows a *digital control valve*, comprising solenoid-controlled orifices in parallel. Each orifice size is related to the other orifices in a binary progression. The flow through each opened orifice adds to that from the other orifices selected and opened so that total throughput can be selected in uniform, discrete steps from zero to full capacity. The nominal pipe size (full flow with all ports opened) is from ½″ to 10″.

Fig. 3 shows a *digital force mechanism*. The output force is proportional to a binary progression by using force cylinders in parallel. Piston area increases in a binary progression. As the heart of most regulators is a force mechanism (spring), this digital force mechanism can be used directly in a digital regulator mechanism. Force mechanisms are available with cylinder sizes from ½″ to 20″, giving forces over a wide range.

A *digital pump* is shown in Fig. 4. Here a crankshaft drives positive-displacement-type pumps or compressor units in parallel. There is a solenoid-operated valve on each unit, which directs the output either to the discharge line (to process) or an unloading return line. The displacement volume of each unit increases as a binary progression, permitting discrete increments of output volume. Rotary positive displacement units also are available.

Fig. 5 shows an incrementally variable *speed transmission system*. The constant-speed motor maintains the input shaft at a constant speed. The binary signal engages selected clutches; the selected drive sprockets are rotated by the turning shaft. The transmission chains move at speeds that are binary proportioned due to the differing radii of the drive wheels. The chain speeds are added by a series of differentials (D units) whose output shaft speed is a sum of the input shaft speed (output of preceding differential) plus its connected chain speed.

Fig. 6 shows a *motor-type (angular) digital positioner*. The positioner is basically the same as the digital transmission except that each drive wheel is powered by a rotary solenoid or torque motor whose shaft is rotated clockwise 360° for the "on" (1) signal, and counter-clockwise 360° for the "off" (0) signal.

A *variable-torque digital clutch* is shown in Fig. 7, comprising a number of electromagnets that are binary proportioned magnetically and a mating induction output plate. By energizing the various magnetic circuits, a digital torque will be realized at the output shaft because the induction plate is attracted to the electromagnetic unit proportionally to the field strength of the electromagnets. Electrical connection to each electromagnet is via slip rings and brushes.

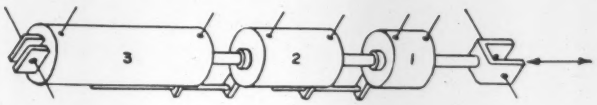


FIG. 1. Linear positioner

FIG. 2. Digital valve.

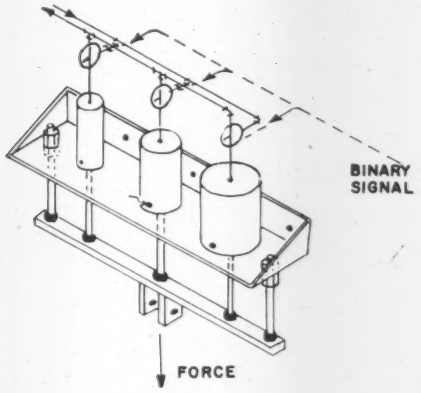


FIG. 3. Digital force mechanism.

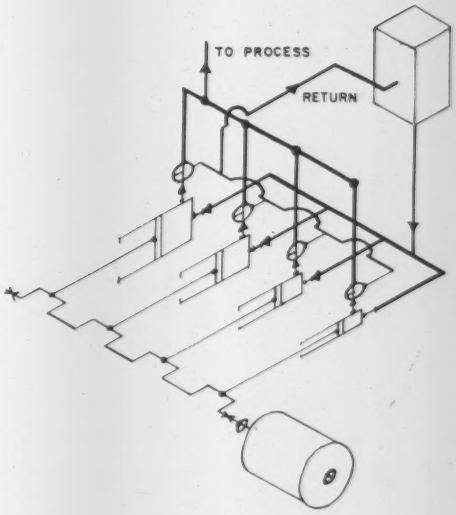


FIG. 4. Digital pump.

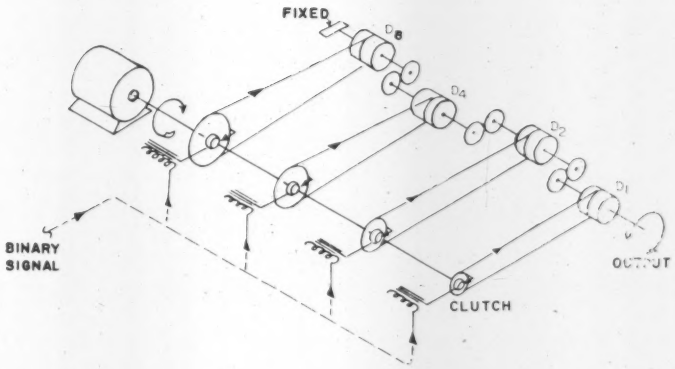


FIG. 5. Digital speed transmission.

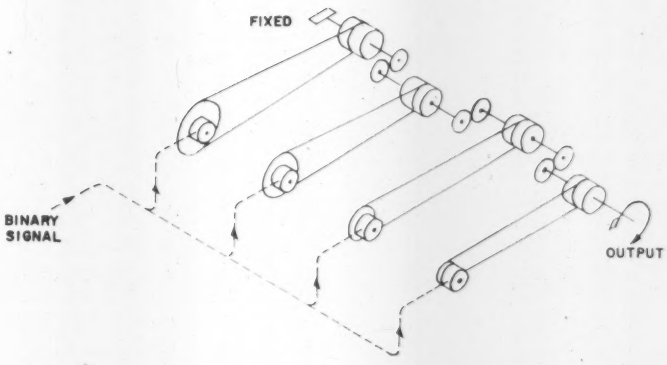


FIG. 6. Angular positioner.

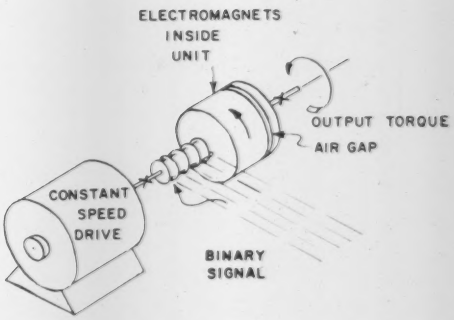


FIG. 7. Digital-torque clutch.

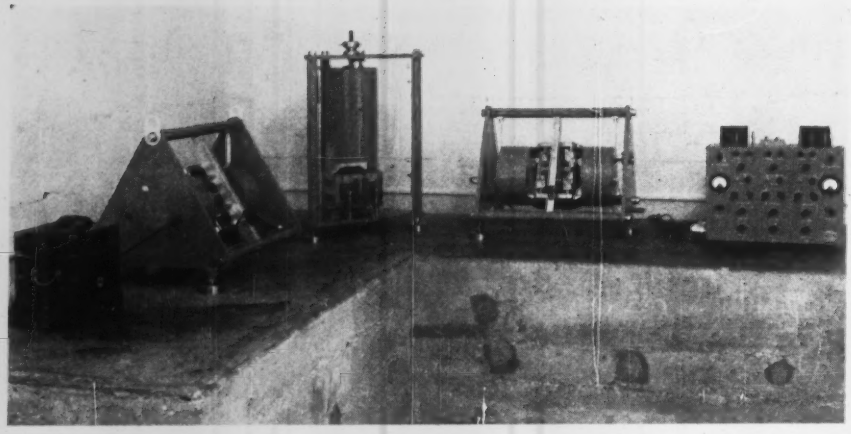


FIG. 1. MODERN STATION seismometer vault has Benioff vertical and horizontal component seismometers mounted on an isolated concrete pier which extends down to bedrock.

Millimicron Motion Instrumentation

Basic transducer types include the variable reluctance, capacity, strain and torsion seismographs. Discussed also are magnification, recorders, vaults and accessories.

JACK McELWAIN
and
R. C. SHOPLAND
The Geotechnical Corporation

DETECTION of millimicron motion requires unusual instrumentation. For that matter, so does the generation or isolation of such infinitesimal motion. This specialized instrumentation is of concern however, to a diversity of activities. For example, certain types of standards and R&D laboratories require seismically-quiet sites and structures. Inertial guidance equipment manufacturers require quiet testing platforms. Reactor operators require immediate notice of small earthquakes. And, of course, such instrumentation is of vital importance to geophysicists and seismologists. To appreciate and understand the principle of seismic equipment, it would be well to briefly review the nature of earth motion.

To the seismologist, the earth is analogous to a peach in structure. The outer skin represents the earth's crust: the pulp represents the earth's mantle (basaltic rock); and the seed represents the earth's core (believed to be composed of liquid nickel-iron). The fracturing of stressed, subterranean rock generates several types of high- and low-frequency seismic waves which travel throughout the interior and crust of the earth.

Short-period waves (5 seconds and lower) which penetrate the earth's dense interior are of two types —longitudinal compression waves analogous to sound waves, and transverse waves analogous to light waves. The longitudinal P (primary) waves are the first to arrive at a seismic station, traveling at speeds approximating 5 miles per second. The transverse S (secondary) waves follow the P-waves at speeds approximating 3 miles per second. S-waves apparently do not pass through the earth's core.

Long-period waves (longer than 5 seconds) are often referred to as surface waves. There are two basic types of surface waves—the Love wave and the Rayleigh wave. The Love wave is the faster of the two, traveling at speeds approximating 2½ miles per second. It is a shear wave, and individual particles of earth move horizontally, transverse to the direction of wave travel. Individual particles of earth in a Rayleigh wave follow a retrograde eliptical orbit in a vertical plane in the direction of wave travel similar to the motion of a surface ripple in water.

A remarkable amount of earthquake and earth structure information is obtained from recordings of short-period seismic waves. For example, the first break of the sharp P-wave provides earthquake timing data not discernible from long-period waves. It will be shown later why Benioff variable-reluctance seismom-

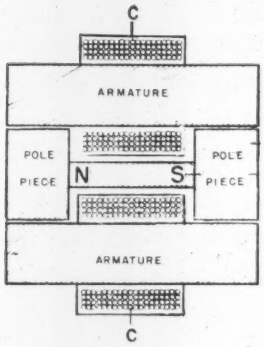


FIG. 2. OPERATING PRINCIPLE of Benioff variable - reluctance seismometer.

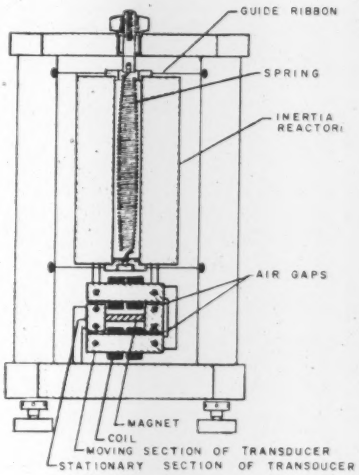


FIG. 3. VERTICAL-COMPONENT variable-reluctance seismometer.

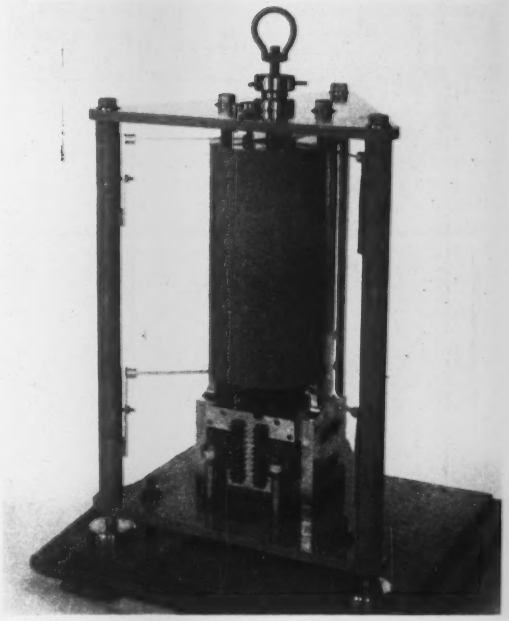


FIG. 4. COMMERCIAL MODEL of vertical seismometer has magnification of 500,000 at one cps, can detect 1×10^{-6} millimeters of earth motion, has electromagnetic damping.

eters are ideal detectors of these very low amplitude waves. Long-period waves are also the subject of considerable study. For example, studies have revealed the correlation of microseismic and meteorological storms. This makes it possible to track meteorological storms with tripartite seismic stations.

Since an earthquake is a three-dimensional phenomenon, seismometers are usually mounted in groups of three: one in the vertical position, one in the horizontal position in an east-west line, and one in the horizontal position in a north-south line. A typical layout of station seismometers is shown in Fig. 1.

Basically, a seismometer consists of an inertial mass suspended from a frame by a weak spring. Seismic waves move the frame while the inertial mass remains stationary. A coil fixed to the mass in the field of a magnet fixed to the frame (or vice versa) generates a current proportional to the relative motion between the mass and the frame. In general, seismomters provide maximum sensitivity to waves of periods less than the natural period of the seismometers.

Early electromagnetic pendulum seismometers such as the Galitzin were among the first to be operated with mirror recording galvanometers. The natural period of this seismometer was 10 to 15 seconds. It employed a moving-coil transducer and a mass of only a few kilograms. In seismic waves of constant power, amplitude varies directly with the period. Best response to P-waves requires the use of a large mass (50 to 100 kg) and a seismometer free period of approximately 1 second. To derive maximum power from a transducer, the pendulum must be damped by the reaction of the output currents. Until recently this type was impracticable. This limitation has been overcome by the development of the variable-reluctance transducer.

Variable-Reluctance Seismometers

The variable-reluctance seismometer was developed by Dr Hugo Benioff of the California Institute of Technology. This instrument is now in general use in seismic stations throughout the world.

In the Benioff seismometer (Figs. 2, 3, and 4) four coils are wound around each of two armatures. The magnet assembly is attached to the frame, and the armature coil assembly is attached to the suspension. Any relative motion between the frame and the armature shortens one pair of air gaps and lengthens the other pair of gaps. The resultant change in field strength induces a push-pull emf proportional to the *velocity* of the relative motion. The eight coils are terminated individually to provide flexibility of operation.

With the introduction of the variable-reluctance seismometer, magnet effectiveness is increased greatly in comparison with moving-coil seismometers. Output power is increased further by the use of a 100-kg mass, while the natural period of the seismometer is re-

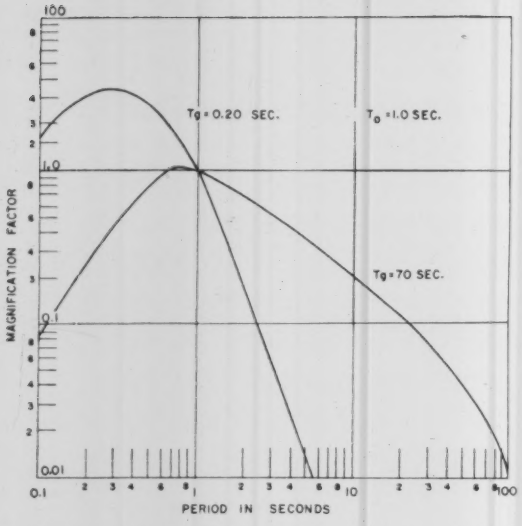


FIG. 5. TYPICAL RESPONSE curve of variable-reluctance seismometer with natural period of one second and galvanometers of 0.20- and 70-second period.

duced to 1 cycle per second. This design also enables the pendulum to be damped by the reaction of the output currents, and consequently no energy is lost due to external damping devices such as are sometimes employed in moving-coil transducers.

The Benioff seismometer has an additional advantage arising from the negative restoring force of the magnetic attraction across the air gaps. Experiments show that, for best operation, the negative magnetic restoring force of a transducer must equal approximately 9/10 the positive mechanical restoring force of the suspension. Thus, for an operating period of 1 second, the mechanical period of a pendulum with no magnetic field is approximately 0.4 second. Benioff seismometers, which have such a transducer, are therefore approximately 6 times as rugged for the same period as are seismometers which do not employ negative magnetic restoring force. In addition, since the air gaps are relatively large (2 mm) compared to earth motion, the instrument does not require close adjustment tolerances, and is less susceptible to variations in environmental conditions.

The 100-kg mass enables the transducer to generate sufficient power to drive several galvanometers simultaneously. Thus each seismometer can drive both short-period (0.2-second) and long-period (90 second) recording galvanometers to cover a broad bandwidth in the seismic spectrum. These seismometers in the short-period combination can provide magnifications up to 1,000,000 at 3 cps, power sufficient to drive galvanometers directly without amplification although separated by distances of 10 miles. A recently developed filtering technique has extended the maximum useful magnification of the long-period combination, which had heretofore been limited by microseismic noise in the 6 to 8 second range. This long-period combination has recorded Rayleigh waves having periods as long as four minutes.

The seismograph installation at Southern Methodist University is an example of a three-component system. It uses one vertical and two horizontal Benioff seismometers to drive three short-period and three long-period recording galvanometers. In addition, the vertical seismometer also drives a direct-writing, hot-stylus drum recorder through a phototube amplifier.

Benioff vertical and horizontal seismometers use identical transducers, providing a matched three-component system. System magnification can be adjusted with electrical controls, eliminating the necessity of mechanical adjustments at the seismometer.

Fig. 5 shows response curves for a 1.0-second period Benioff seismometer driving a short- and long-period galvanometer. The curves are normalized at 1 second. The magnification at this ground frequency can be made to exceed 500,000 by the proper choice of coil connections.

Benioff seismometers can be calibrated locally or remotely by use of a weight-lift technique. Test weights as small as 55 milligrams are allowed to rest against the mass of the seismometer. When the weight is lifted by a solenoid, the resulting transient will calibrate the seismograph at a given frequency, and will permit a comparison of magnifications among several units.

The response curves for the short-period combination were obtained by placing the seismometers on extremely small-amplitude shake tables developed by The Geotechnical Corporation. These tables employ mechanical and hydraulic drives to produce accurate transient and sinusoidal motion equivalent to earthquake motion.

Capacitance-Transducer Seismometers

Capacitance transducers are valuable in determining earth displacement. In this type of seismometer the relative motion between the mass and the frame moves a plate positioned between two fixed capacitor plates. This movement produces opposite changes in the capacity of the two capacitors which serve as elements of a discriminator circuit. The circuit is energized by a stable high-frequency oscillator. The result is a linear discriminator with negligible response to input voltage variations. The output voltage of the discriminator is proportional to the actual displacement of the mass relative to ground motion rather than to velocity, as in the electromagnetic transducer.

The unamplified, rectified output of the discriminator is sufficient to drive galvanometers directly. With amplification the output can drive recording pen-motors or be recorded on magnetic tape. The tapes can be played back at higher speeds to provide a means of seismic spectrum analysis. One oscillator can be used to energize several remote seismometers.

Strain Seismometers

The strain seismometer (Fig. 6) developed by Dr Benioff responds to strains in the earth's crust caused

by seismic waves. The strain rod, often as long as 60 feet, is surrounded by a layer of flexible heat-insulating material to reduce length variations due to temperature changes. The rod is supported laterally by a number of axially-compliant transverse members. Variable reluctance and moving-coil transducers may be used; however, by employing a capacitance transducer the response to long-period waves is increased. Response to long-period waves is enhanced further by using a long-period recording galvanometer which has a very high sensitivity and is relatively insensitive to unwanted high-frequency signals. The response of this system to long-period Love and Rayleigh waves is limited only to variations in length of the rod due to temperature changes. Dr. Benioff is presently operating a capacitance-transducer strain seismometer using a fuzed quartz rod mounted in an underground tunnel in order to minimize temperature variations. The system uses a 5.35-Mc oscillator which is crystal controlled for stability. The seismometer has recorded numerous waves of 300-second periods, and has actually recorded a wave whose period was 3,400 seconds—nearly an hour.

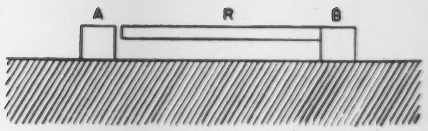


FIG. 6. STRAIN SEISMOGRAPH has tube of steel or quartz (R) attached to one pier (B) and extending close to another (A). The change in separation between A and R, which is proportional to ground strain, is detected, magnified and recorded.

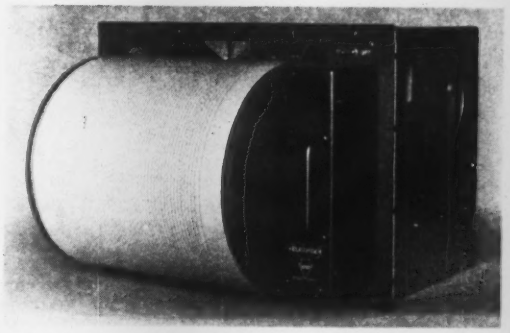


FIG. 7. Helicorder is hot-stylus drum recorder; records 8 to 72 hours of data on a 12" x 36" record.

Torsion Seismometers

Torsion seismometers, such as Wood-Anderson seismometers, are relatively simple devices which serve both as seismometer and galvanometer. These instruments consist of a vertical taut wire in the center of which is attached a copper vane. It resembles a flag at half-mast. A mirror attached to the copper vane reflects light to a photographic recorder. Horizontal earth motion causes the light beam to deflect. Eddy current damping is accomplished by placing a permanent magnet in the vicinity of the copper vane. This type of seismometer is used for local earthquakes, and has a period of about 0.8 second and magnification of 2800. The teleseismic version of this instrument has a period of 6 to 8 seconds, and a magnification of from 300 to 1000.

Seismic Recorders

Seismic recorders differ primarily from industrial recorders in that seismic recorders must be capable of long-term operation, and the records must display hours of data at a glance. Consequently, many seismic recorders use drum transports around which a 12" x 36" chart is wrapped. Traces are recorded helically so that, when the record is removed, hours of data may be studied and compared as conveniently as the type on this page. Mirror galvanometers are placed behind the drum of photographic paper and film recorders. As the galvanometers reflect light to the record wrapped around the drum, the drum slowly translates axially as it revolves, scribing helical traces. The sensitivity of short-period galvanometers used with Benioff photographic recorders is 3×10^{-8} amp/mm/meter. The sensitivity of a 90-second galvanometer is 9×10^{-11} amp/mm/meter.

The new direct-writing Helicorder (Fig. 7) has advantages in that data is immediately visible, and a dark-room is not required. As the drum revolves, the pen-motor slowly translates axially, again scribing compact, helical traces. Both drum and translation speed are adjustable.

An advantage of drum recorders is obviously the economy of recording many hours of data on a single sheet of paper or film.

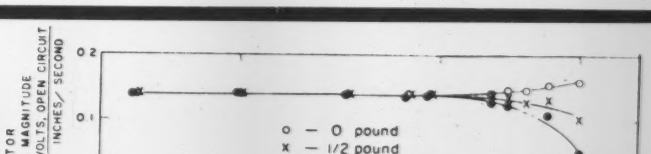
Accurate timing pulses are fed direct to the pen-motor of a direct-writing drum recorder, and to the light source of a photographic recorder.

Further size reductions have been realized through the use of 35-mm and 70-mm film. This film yields additional economy and storage convenience. Copies of films can be made readily, and data can be projected for study. A recently developed recorder records 16 channels of data on 16-mm film, automatically processes the film internally, and displays the data magnified ten times on a self-contained view-screen.

Seismic-Station Vaults

For permanent seismic-station installation, seismometers are mounted on concrete piers whenever possible. Piers are often sunk to bedrock to provide maximum coupling to the earth, and to isolate the seismometers from high-energy local noise transmitted by unconsolidated rock and alluvium. A gap of several inches is usually left between the pier and the floor to further isolate the seismometers from unwanted seismic noise.

Recorders can be mounted on platforms in the vault. Using powerful Benioff seismometers, recorders may also be located up to ten miles from the seismometer vault.



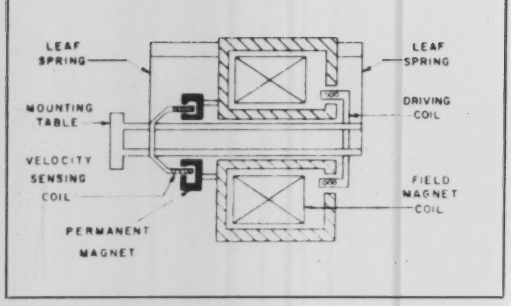


FIG. 1. SCHEMATIC CROSS-SECTION of electrodynamic vibration-pickup calibrator used by the National Bureau of Standards.

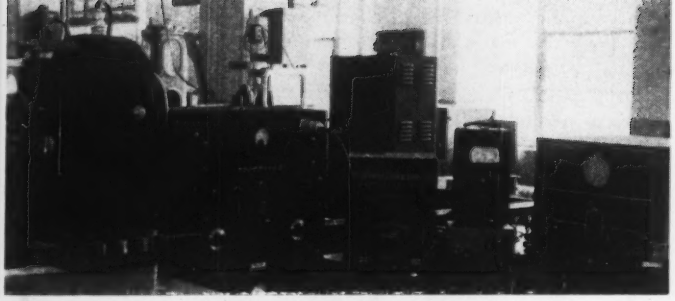


FIG. 2. APPARATUS USED IN transfer admittance measurements. Electrodynamic calibrator at left center is shown with a weight (hexagonal cylinder) attached to its mounting table (left side)

Vibration Pickup Calibration

National Bureau of Standards has developed a method for standardizing electrodynamic calibrators which makes possible a limited NBS calibration service for vibration pickups measuring displacement, velocity, or acceleration.

R. R. BOUCHE
National Bureau of Standards

AN ELECTRODYNAMIC CALIBRATOR for vibration pickups consists of a vibration exciter with a built-in vibration measuring device. It produces mechanical vibrations by electrical means and, simultaneously, generates an electrical output that depends on the vibration. The calibrator is standardized by determining the relationship between its electrical output and the vibratory motion.

Once an electrodynamic calibrator is standardized, the procedure for calibrating a pickup is straightforward. The pickup is attached to the mounting table of the calibrator and is set in vibration at the desired amplitude and frequency. The amplitude can be set accurately and the frequency can be measured accurately. It then remains only to compare the voltage output of the calibrator with that of the pickup.

The NBS method for standardizing the calibrator is based on research (by S. Levy and R. R. Bouche) in reciprocity theory, and avoids direct measurement of the vibratory motion. It can be used above as well as below certain resonances in the calibrator. It is necessary only to measure frequencies, currents, and voltages in the calibrator when (1) several known masses are attached to the mounting table, and (2) when the calibrator is forced to vibrate by an external vibration exciter.

Electrodynamic Calibrator

The electrodynamic calibrator for which the present method has been developed has three moving components—driving coil, mounting table, and velocity-sensing coil (Fig. 1). In the calibrator studied these parts are joined by a shaft to form a single mechanical unit suspended from a frame by leaf springs. A field magnet coil is near the driving coil and a permanent magnet is near the velocity-sensing coil. When alternating current is passed through the driving coil the moving parts vibrate. At the same time an alternating voltage is generated in the velocity-sensing coil.

The calibrator must be standardized—that is, the relation between the electrical output of the velocity-sensing coil and the velocity of the table must be determined. The reciprocity method enables this relation to be calculated without requiring a detailed knowledge of the calibrator structure.

Reciprocity Theorem

Reciprocity theory was first applied to electrical circuits. In the case of a passive linear network, the basic theorem is that if a source of emf is placed in branch A of the network, the current produced in branch B is the same as the current produced in branch A if the same emf were inserted in branch B.

As applied to the electrodynamic calibrator, the reciprocity theorem used states that the ratio of mechanical force at the mounting table to the driving-coil current when the velocity of the table is zero (i.e., when it is held fixed) is equal in magnitude and

From Summary Technical Report 2076

MISSILE IMPACT TELEMETERING TRANSMITTER DEVELOPS 65 MW AT 65 MC

In making impact tests of missiles on a rocket-sled test range, available free-flight telemetering equipment

FIG. 3. APPARATUS USED IN second part (voltage ratio measurements) of NBS reciprocity method for standardizing electrodynamic vibration-pickup calibrators.

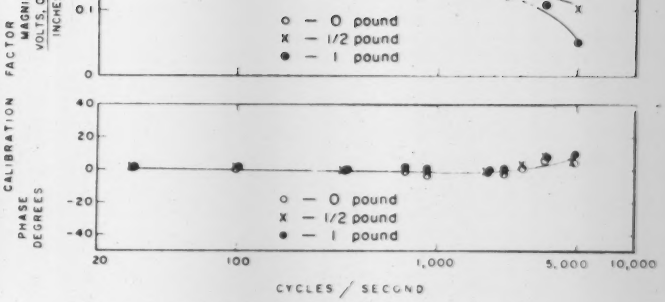


FIG. 4. CALIBRATION FACTOR of a typical electrodynamic vibration pickup calibrator obtained by using the reciprocity method.

opposite in phase to the ratio of the terminal voltage of the driving coil to the mounting table velocity when the driving-coil current is zero (i.e., when its circuit is open).

Standardization Procedure

Standardization of the calibrator determines the calibration factor (F), the ratio of induced voltage in the velocity-sensing coil to the mounting table velocity. The factor depends mainly on the characteristics of the calibrator itself, but also is influenced at higher frequencies by the mechanical impedance of the pickup attached to the table.

When a vibration pickup is attached to the table and the driving coil is energized with alternating current at any particular frequency, the theory shows that

$$F = a + bY_p \qquad (1)$$

where Y_p is the mechanical impedance of the pickup and a and b are constants that depend on the construction of the calibrator. All the symbols stand for complex numbers in the manner used in alternating-current theory. Thus, Y_p is the complex number that represents in magnitude and phase the ratio of the sinusoidal force applied to the pickup to the resulting sinusoidal velocity. The aim of the standardization procedure is to determine the constants a and b. In computing their values, transfer admittance and voltage ratio measurements are made.

The transfer admittance (G_w), which is the ratio of driving-coil current to velocity-sensing coil voltage, is measured with each of several weights, W, attached to the mounting table (Fig. 2). The transfer admittance, (G_o) with no weight attached, also is measured. Then, for each weight attached to the table, the ratio $W/(G_w - G_o)$ is computed. This is repeated at each frequency for which the values of a and b are desired. For each frequency, the real and imaginary parts of the computed ratio are plotted against W.

For the voltage ratio measurements, the mounting table of the calibrator being standardized is connected mechanically to that of another electrodynamic calibrator or other vibration exciter (Fig. 3). The driving coil in the latter is energized and the ratio (R) of the open-circuit voltage generated in the velocity-sensing coil to the open-circuit voltage in the driving coil is measured. This is done for each of the frequencies used in the transfer admittance measurements.

Once these measurements have been made, the constants a and b are computed from:

$$a = 0.01711\sqrt{j\omega R}$$
$$b = 6.601Q\sqrt{R/j\omega J} \qquad (2)$$

where ω is the frequency in radians per second and j is the unit imaginary vector. The terms J and Q are the ordinate intercept and slope, respectively, of the plot of $W/(G_w - G_o)$ versus W. This completes the standardization procedure and the calibration factor can be computed from equation (1) if the mechanical impedance of the pickup to be attached to the mounting table is known.

The procedure is illustrated by results obtained for a typical electrodynamic calibrator with a nominal 50-lb driving force rating. Calibration factors for this instrument were computed from equation (1) for pickups with mechanical impedances corresponding to weights (W) of 0, 0.5, and 1.0 lb. (Y_p is then equal to $j\omega$ W/g, where g is the acceleration of gravity (386 in/sec^2). The magnitude and phase angle of these calibration factors are plotted against frequency in Fig. 4. This particular calibrator is independent of frequency and pickup weight up to 900 cps.

One method of calibrating a pickup is to energize the driving coil of the calibrator at the desired frequency and drive the calibrator at the desired amplitude as indicated by the voltage in the velocity-sensing coil. From this indicated voltage and the value of F obtained from equation (1), the velocity of the mounting table is found by a simple division because F is the ratio of velocity-sensing coil voltage to mounting-table velocity. The output of the pickup corresponding to this velocity is then measured. The calibration factor of the velocity pickup is then the ratio of the output of the pickup to the velocity of the mounting table. Similarly, the calibration factor of an accelerometer is the ratio of pickup output to table acceleration.

ential preamplifier (gain = 20), the signals are impressed on the input of this circuit, which comprises an audio oscillator-modulator, amplifier, and radio-frequency oscillator-modulator.

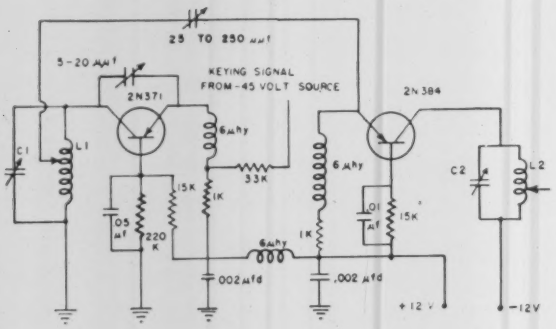
ELECTRONIC

The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

MISSILE IMPACT TELEMETERING TRANSMITTER DEVELOPS 65 MW AT 65 MC

In making impact tests of missiles on a rocket-sled test range, available free-flight telemetering equipment was found to be unsuitable. This circuit was developed as a short-range transmitter for telemetering time signals, developing 65 mw power output at 65 Mc. It is desired to measure the time after impact when a given structural member within the missile fails. When the missile contacts the target, a switch is closed, starting a counter chronograph. A second switch contact is made when structural failure occurs; this signal is used to key the transmitter output off. The corresponding output at the radio receiver is used to stop the chronograph timing, and the elapsed time is read from the counter chronograph.

The two transistors are used in the grounded-base mode to obtain improved high-frequency performance. The 2N371 transistor is used as a grounded-base oscillator, operating in the 20-40 Mc range. The feed-back capacitor (5-20 uuf) between emitter and collector is adjustable to allow optimum feedback. Adjustment of this capacitor



permits tuning out the inductive effect of the emitter coil and the current phase lag due to the transit time of charges within the transistor.

Emitter of the second stage is driven from a tap on the oscillator tank coil. Second stage is a frequency-doubling amplifier, using a type 2N384 transistor. Coupling capacitor is adjustable to permit tuning out the inductive input impedance of the second stage to obtain maximum power. Second-stage tank circuit is tuned to twice the oscillator frequency; antenna is driven from an adjustable tap on the tank coil.

Transmitter output is keyed off by applying a negative voltage (above 1.4 v) at the emitter of the oscillator, cutting off the transistor. This keying signal was taken from a —45 v source. With the 200-kc-bandwidth receiver used, the system produces reliable time measurements down to a few microseconds; in its present form, resolution of times under 1 us is not feasible.

Output Frequency: 40-80 Mc.

Power output: 65 mw at 65 Mc, into 50-ohm resistive load.

Keying Signal: —45 v.

Power Supply: ±12v d-c at 10 ma.

Source: J. L. Wright and J. C. Ruscus, Ordnance Corps., Picatinny Arsenal, Dover, N. J.; also *IRE Transactions on Space Electronics and Telemetry*, June, 1959

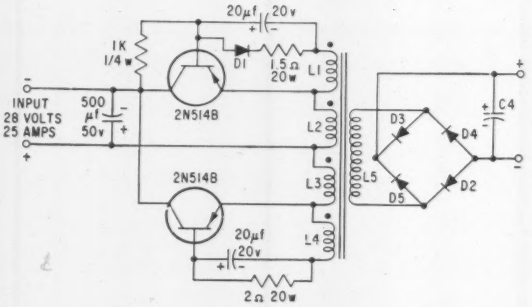
630-WATT D-C TO D-C CONVERTER HAS 90% EFFICIENCY

Two germanium type 2N514B transistors, rated at 80 v, 25 a each, convert 630 watts of 28 v dc to a different output voltage. The transistors are transformer-coupled to form a relaxation oscillator operating at about 1 kc.

When 28-v power is initially applied, the upper transistor conducts first because of the base current fed to it via the 1K resistor to —28 v. Diode D1 prevents this base current from being shunted by the 1.5-ohm base resistor. Emitter current of the upper transistor, flowing in L2, produces, by transformer action, voltages at the base and emitter of the lower transistor (across L3 and L4) which keep that transistor from conducting. At the same time, voltage developed across L1 produces increasing base current, further augmenting the flow of emitter-to-collector current in the upper transistor.

As current in L2 continues to increase, saturation of the core is approached, current in L2 stops increasing, and the voltages induced in the other windings fall to zero. As the emitter current flowing in L2 decreases, polarity of all induced voltages reverses, and the lower transistor goes into conduction; the upper transistor is rapidly cutoff by regenerative action. The 20-uf capacitors are charged by emitter-to-base currents, providing self bias (base positive with respect to emitter). This self-bias permits low average currents in the transistors and high efficiency.

Output is taken from winding L5 and rectified by the



CIRCUITRY

CHARLES F. KEZER

and

MILTON H. ARONSON

full-wave bridge D2-D5. Winding L5 can be wound for the desired output voltage and current (amounting to no more than 630 watts), allowing 0.639 turns per volt. Wire size must be large enough to allow one circular mil per ampere. Diodes in the full-wave bridge should be chosen for current carrying capacity and peak inverse voltage rating as required by the output chosen.

For operation to 50°C, each transistor must be mounted on the equivalent of at least 200 sq in of ¼" thick aluminum; the heat sink for diode D1 is a minimum of 1 sq in of 1/16" thick aluminum.

Input: 28 v dc, 25 amps.
Output: As required by winding L5 to order (see text), 640 watts max.
Frequency: About 1 kc.
Core: Magnetics, Inc. type 50522-2A.
Windings: L1, L2, 4 turns each #16 wire; L2, L3, 17 turns each #10, bifilar wound.
Source: Texas Instruments, Inc., P. O. Box 312, Dallas, Texas.

SHORT-RANGE RADIO TELEMETER FOR MEDICAL USE

Electrocardiographic recording is ordinarily accomplished by connecting wires to electrodes on the patient's body from amplifiers and associated recorders. In order to make recordings while the subject is walking, this circuit was developed to transmit the signals, using amplitude-modulated audio subcarriers, which are in turn frequency-modulated on a VHF carrier.

Signals at the electrodes are 0.1 to 3 mv in amplitude, superimposed on skin potentials of 50-100 mv. Frequency range is d-c to 1000 cps. After passing through a differential preamplifier (gain = 20), the signals are impressed on the input of this circuit, which comprises an audio oscillator-modulator, amplifier, and radio-frequency oscillator-modulator.

Transistor Q7 is a Colpitts oscillator, using a high-Q tank circuit. Carrier frequencies range from 600 cps to 4.35 kc. The thermistor between the base of Q7 and ground improves temperature stability.

With R1 disconnected, the oscillator would develop 9.5 v peak-to-peak at the tuned circuit; in operation, however, loading by R1, R2, and the base of Q8 reduces the audio level to 220 mv at the base of Q8. This signal may be 90% amplitude modulated by application of a 60-mv peak-to-peak signal to the base of Q7. Linearity of modulation is good up to 80%. Additional audio channels from other modulators would be combined at the base of Q8.

The amplified modulated audio output appearing at the collector of Q8 is applied to the emitter of Q9, the radio-frequency oscillator-modulator. Q9 oscillates at 104 Mc; its collector capacitance is varied at audio frequency rate by the emitter voltage variations. As collector capacitance is part of the tuned circuit, the oscillator is frequency-modulated by the audio input.

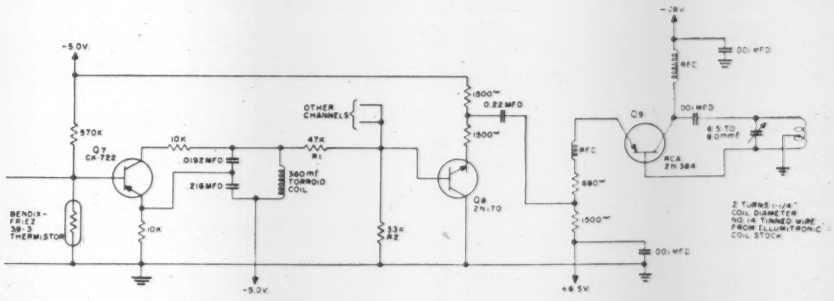
No antenna is used, as sufficient radiation is obtained, at 75 mw power input to the collector, for transmission up to 100′ indoors. Up to 500′ range is obtained outdoors. Transmitter is stable in operation, requires no field adjustments, and is not affected by shaking.

Input: Electrocardiograph signals from EKG preamp, 2-60 mv max., bandwidth, 3 db points, 275 cps.
Output: Frequency-modulated carrier, 104 Mc.
Ambient temperature: 70°-90°F.
Power supply: Batteries, 28 v at 3 ma; 5 v at 1 ma.
Battery life: 120 hours.
Source: H. G. Beenken and F. L. Dunn, U. of Nebraska College of Medicine, Omaha, Neb.; also *IRE Transactions on Space Electronics and Telemetry*, June 1959.

"An ideal reference text . . ."

100 ELECTRONIC CIRCUITS

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phototube circuits, phase shifters, etc. Complete with all circuit component values and response specifications. paper, 180 pages, illustrated $2.00, Instruments Publishing Company.

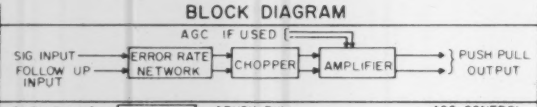
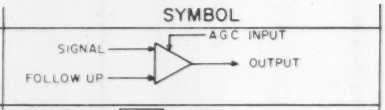
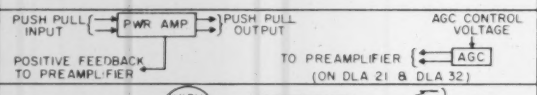
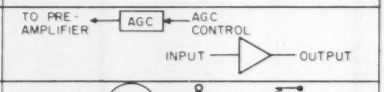
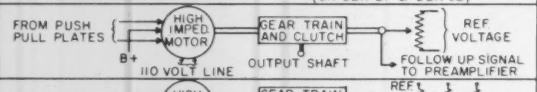
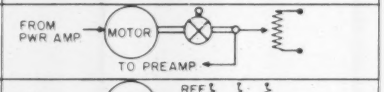
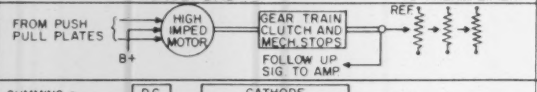
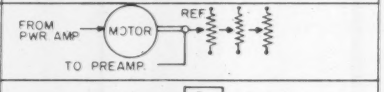
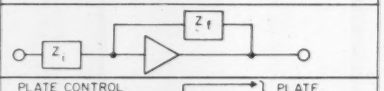
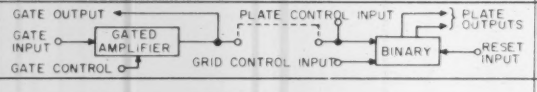
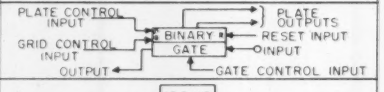
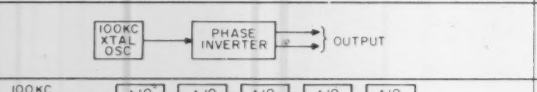
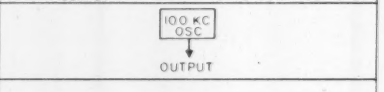
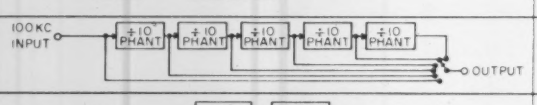
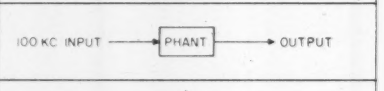
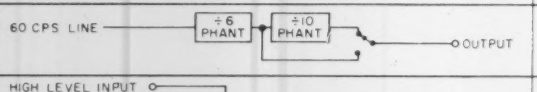
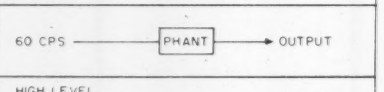
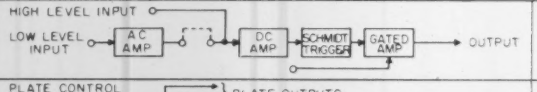
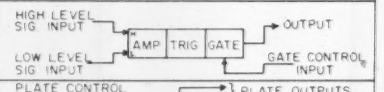
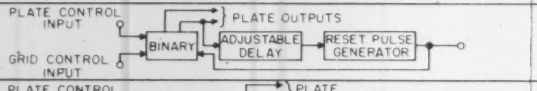
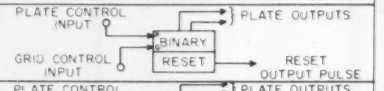
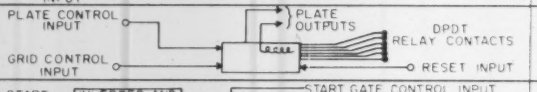
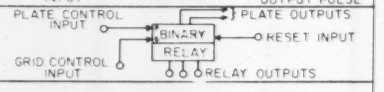
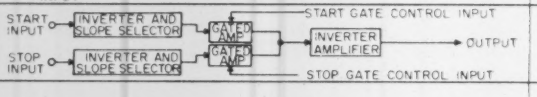
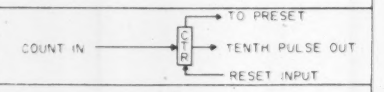
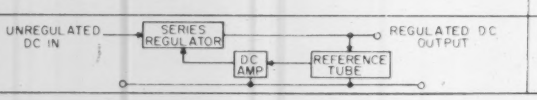
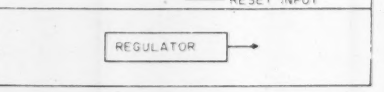


"Digitrol" Building Blocks

Design of control systems and special-purpose instrumentation can be simplified by relying on plug-in stages linked together to provide the necessary action. Here are some of the many possible combinations.

JOHN H. HOSEMAN
Electro Precision Corp.

TABLE I—COMMON FUNCTIONS AND DEVICES FOR COMPUTING AND CONTROL

MODEL	FUNCTIONS	BLOCK DIAGRAM	SYMBOL
DLA-11	SERVO PREAMPLIFIER		
DLA-20-21 DLA-31-32	POWER AMP W/OPTIONAL AGC		
DLS-10	SERVO ACTUATOR		
DLS-21	SERVO MULTIPLIER		
DLA-41	OPERATIONAL AMPLIFIER		
DLD-31	BINARY AND GATE		
DLD-60	CRYSTAL CLOCK		
DLD-61	FREQUENCY DIVIDER		
DLD-62	FREQUENCY DIVIDER		
DLD-70	AMPLIFIER TRIGGER GATE		
DLD-100	BINARY AND RESET		
DLD-110	BINARY AND RELAY		
DLD-120	TIME INTERNAL CARD		SAME AS BLOCK DIAGRAM
DLD-10 SERIES	DECADE COUNTERS	A SERIES OF DECADE COUNTERS WITH ANALOG, 4 LINE BINARY, AND METER OUTPUTS. NEON INDICATORS.	
DLX-11	VOLTAGE REGULATOR		

A SUBSTANTIAL AMOUNT of engineering time is invested in detailed circuit design. A compatible set of pre-designed functional components can reduce these costs for special-purpose control systems and computer design. This is especially true if these functional elements are plug-in or can be grouped quickly so the engineering will consist essentially of tying together the functional components.

A large number of special-purpose computers, instruments and control systems were analyzed and broken up into block diagram form. These block diagrams were regrouped a number of times to establish the minimum number of functional elements which would yield the largest number of configurations. Table 1 shows the results of this study. Here are a few of the instruments and devices which can be assembled from these individual building blocks.

Sample Groupings

Fig. 2 is a block diagram of a divider assembled from the basic building blocks. For more accurate division over a wider range of parameters the circuit of Fig. 3 can be used. In Fig 3, $Y = E_{REF}(\theta)$; $E_2 = E_o(\theta)$; $E_2 = -X$ (because DLA 41 is an operational amplifier used as inverter). From these relations, $E_o = E_{REF}(-X/Y)$.

An interesting application of servo components is shown in Fig. 4. Here the problem involves regulation, first to a preset current in a highly-variable load until the voltage required to maintain the preset current has built up to a predetermined maximum. At this point the control mode is switched from constant current to constant voltage. The control system is that of a servo regulator. When the system is initially placed into operation, the control mode is based on controlling to a preset current. To accomplish this the voltage must be increased slowly because the load changes with time in such a way that impedance is increased. When the preset voltage limit is reached the operational amplifier, functioning as a comparator, triggers a fast cross-over. This operates the relay which switches from the current transducer and the preset current command signal to the voltage transducer and the preset voltage command signal. Control is accomplished by servoing a Variac in the input of the power supply. Current and voltage transducers in this application consist of properly selected resistance ladders. Both voltage and current regulation accuracy of better than 0.1% can be achieved at currents as high as 50 amperes.

If an a-c servo bridge is used as part of a control loop, it may be desirable to count the number of times that the error signal in the servo exceeds a predetermined level and initiate a secondary control action by a relay each time this situation occurs; the block diagram of Fig. 5 will accept the a-c input from the bridge circuit. When this input first exceeds the threshold level (adjustable from 0.1 to 100 v) a trigger pulse will be generated and passed through a gate to operate a hi-stable flip flop. This will operate the relay, and at the same time will close the gate so that succeeding a-c waveforms will not be passed as long

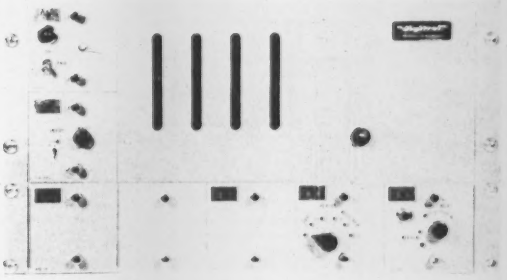


FIG. 1. FREQUENCY METER made up of building blocks.

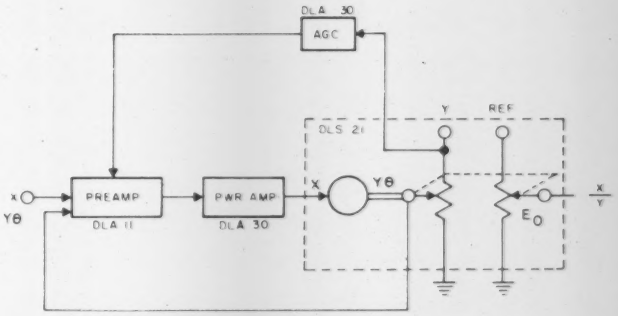


FIG. 2. SINGLE-QUADRANT divider; both X and Y are restricted to positive values. Servo moves pot slider through angle θ until $X = Y\theta$ at balance; as $E_o = E_{REF}(\theta)$, hence $E_o = E_{REF}(X/Y)$. AGC is used only for stability.

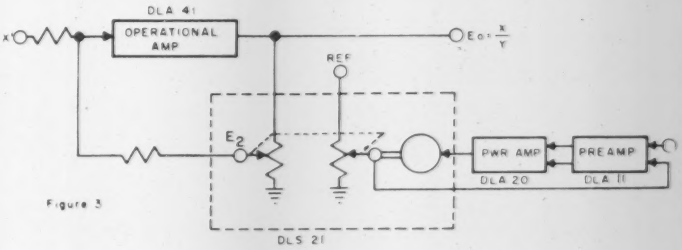


FIG. 3. DIVIDER with improved accuracy.

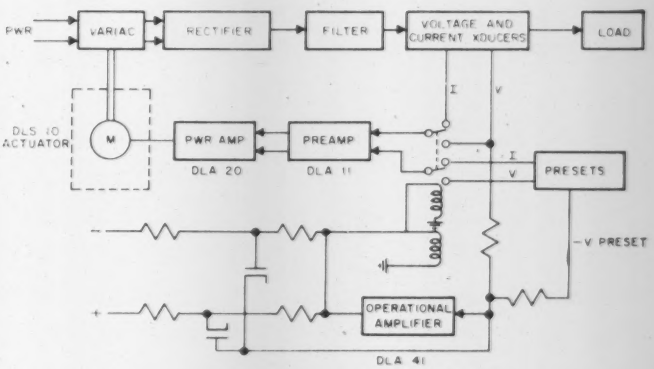


FIG. 4. CURRENT-VOLTAGE regulator.

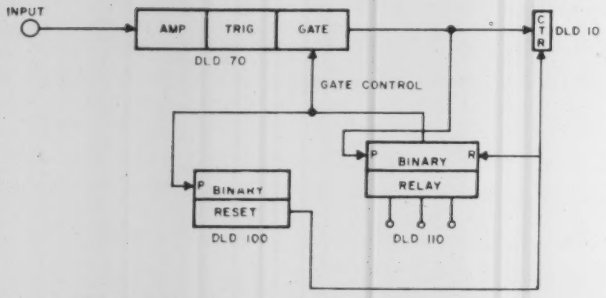


FIG. 5. COUNTER shows number of times servo error voltage exceeds preset level.

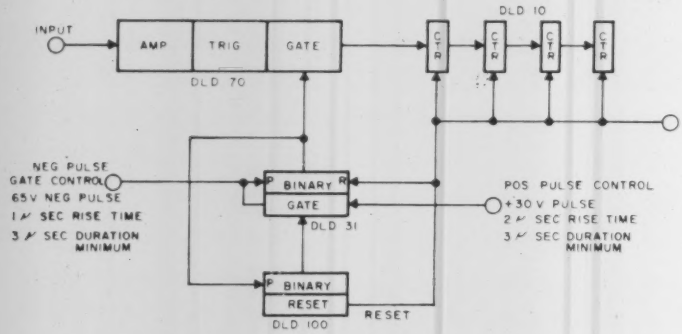


FIG. 6. COUNTER is gated by an external signal.

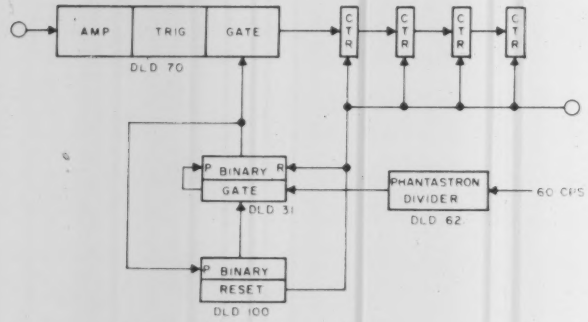


FIG. 7. FREQUENCY METER is based on line frequency.

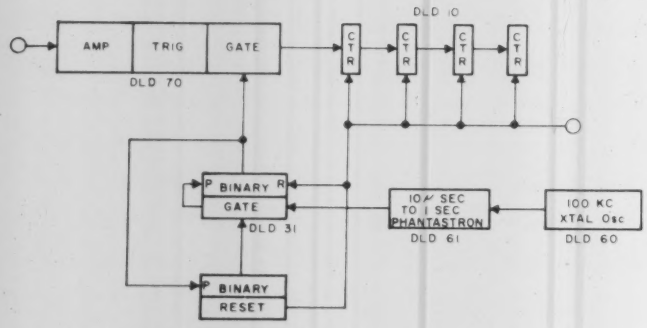


FIG. 8. CRYSTAL OSCILLATOR improves time base of frequency meter.

as the relay is closed. The flipping of this binary will also initiate the time delay in the reset circuit. This time delay is adjustable over a range between 0.1 and 15 seconds, or the reset can be operated manually. At the end of this delay, a pulse will be generated which will reset the relay and the gate, thus making the unit ready for the next input pulse. A single decade counter counts the number of relay operations.

An interesting series of circuits can be built up around a bank of four to six decade counters, an amplifier-trigger-gate and a regulated power supply. Fig. 6 shows a counter which can be gated by an external positive or negative signal. Automatic or manual reset is provided by the optional binary and reset building block and a binary and gate building block. Counting rates up to 100 kc are possible. This counter counts events between two pulses which can be either positive or negative. It resets automatically for the next sequence after a preset readout delay time. The reset pulse is available to external equipment for synchronization if desired.

Fig. 7 adds another element to the circuit shown in Fig. 6, in that a marker generator consisting of a pair of phantastrons derive a timing signal from the 60-cycle line and yield time signals of 0.1 and 1 second. Thus a frequency meter with a basic accuracy of the line frequency is available.

This frequency meter is further refined as shown in Fig. 8. Here the time-base accuracy is improved over the line frequency by adding a crystal oscillator in the phantastron chain. This particular phantastron has 5 outputs, and time bases from 10 microseconds to 1 second are available. Both Figs. 7 and 8 incorporate an adjustable delay in the reset circuit so that display time of from 0.1 to 10 seconds is available, or an indefinite delay is available. The built-up unit of Fig. 8 is shown in Fig. 1.

Many other groups can be put together in this manner to do simple jobs; refinements can be added by increments.

Interconnection between the various modules can be made rapidly and accurately by use of *interconnect cards* (Fig. 9) that contain all necessary wiring. Thus even the wiring is modularized.

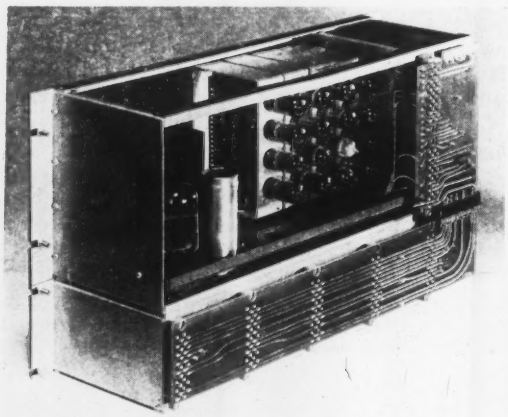


FIG. 9. INTERCONNECT CARDS for rapid wiring.

CIRCLE 70 ON READER-SERVICE CARD

controls

for pressure, liquid level, temperature and flow

Mason-Neilan offers one of the widest and most versatile lines of control devices, designed — from primary to final control element — to provide superior performance.

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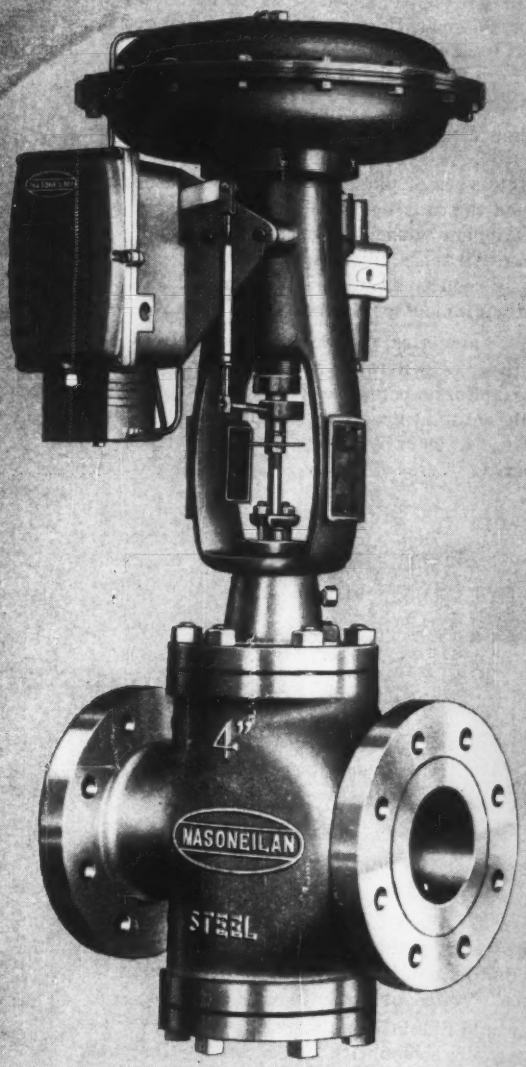
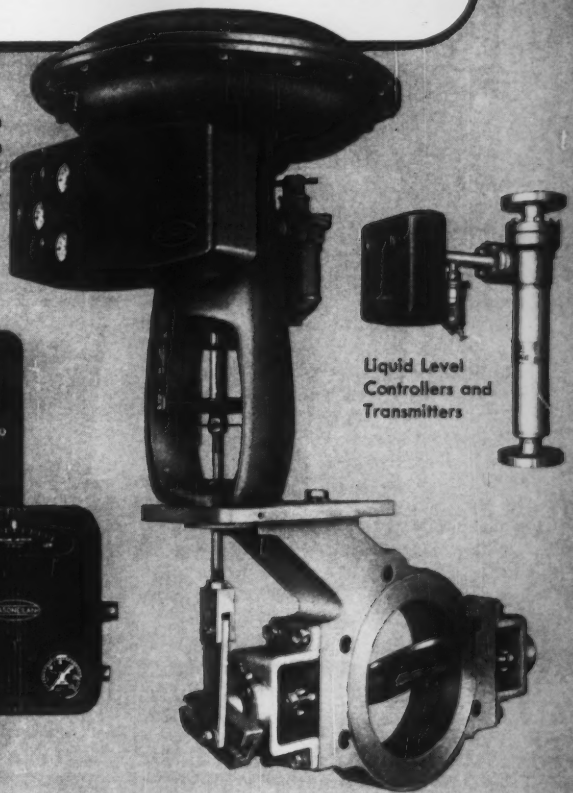
MNS-56

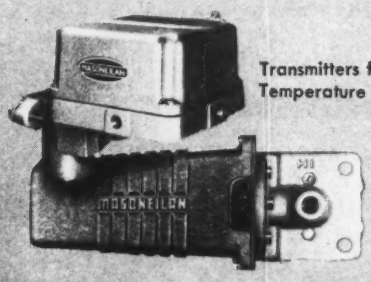


Control Valves shown with Electropneumatic Positioner

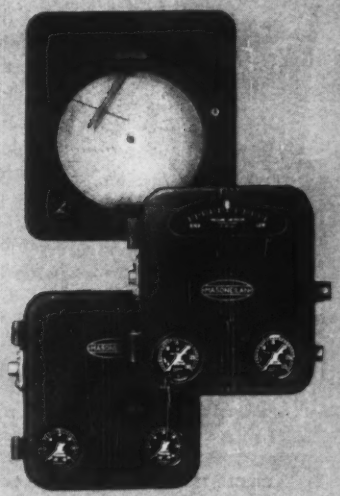
Butterfly Valve shown with Spring-diaphragm Actuator and Pneumatic Positioner



Liquid Level Controllers and Transmitters



Transmitters for Pressure, Temperature or Flow



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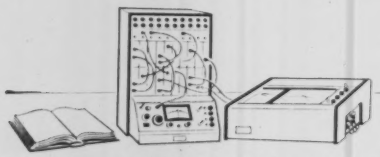

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Long Branch, New Jersey

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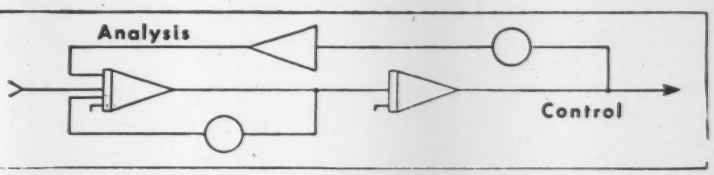
The SIMULATION COUNCIL



Newsletter

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Suzette McLeod, SECRETARY

8484 La Jolla Shores Drive,
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Bits

Last month we promised a writeup of the final paper given at the January meeting of the Midwestern Simulation Council, so we lead off this issue with *Klaus Frielinghaus*' description of an automatic railroad-car classification yard.

Next we report the first half of the April meeting of the Midwestern Simulation Council* with our version of talks by *Jim Elgin* on "Computer Study of Recoverable Boost Propulsion Systems" and *A. J. Cacioppo* on "Human Factors in Aircraft Control." Also included is our reason for skimming over presentations by *Walli* and *Franke* on "Optimum Mission Profile Simulation" and *P. J. Hermann's* "Simulation for Guidance Systems."

We conclude **Pieces** with a partial writeup of the May meeting of the Central Simulation Council. Speakers and papers were: *C. H. Thomas*, "Analogue Computer Study of Pulse-Duration and Pulse-Frequency Modulated Control System"; *B. G. Strait*, "A Position Servo with Multiplicative Velocity Feedback"; *Harvey J. Wertz* and *J. L. Starr*, "Predicting Non-linear Servo Oscillations from Harmonic Frequency Describing Functions"; *William Comley*, "Simplifying Non-Linear Control Systems with the Quadratron"; *Philip G. Kirmser*, "Theory of the Single Input-Output Experiment."

Pieces

Frielinghaus on Railroad-Yard Automation

This month we lead off **Pieces** with the final paper of the Midwestern Simulation Council's January meeting, which we were unable to finish last month. It was a description by *Klaus Frielinghaus* (General Railway Signal Company) of a fully automated railroad yard which uses analog-computer components for the automation.

Railroad-car classification is analogous to the letter-sorting operation that takes place in the post office, but instead of letters being sorted into different pigeon holes, freight cars are sorted into different storage tracks, each one designated for a different destination. When a storage track fills up, a train for that destination can be made up.

There are many types of classification yards, but the one described here is the gravity type, where cars are pushed over a small hill, or hump, and then allowed to roll free under the force of gravity to their particular storage, or class track. At the crest the cars are separated into "cuts," consisting of one or more cars, depending on their destination. The cut of cars first passes through a hump retarder, which consists of long vise-like clamps on the rails which squeeze the wheels to slow the car to a desired speed. From there the car is routed to a group where it is retarded again by the group retarder. Since the group retarder is the last controlling device which can alter the velocity of a cut, its operation is the most critical if a safe coupling speed in the class tracks is to be achieved (between four and five mph for fragile loadings). When a class track fills up, the track is pulled out from the car end and is made up into a train.

In very early gravity yards the cuts were controlled by riders who manipulated the hand brake to provide a safe coupling. This operation was extremely dangerous and required a large number of men. The next evolution was the retarder, which was controlled by a retarder operator. Since the cut usually rolls several thousand feet to coupling after passing through the last retarder, the operator had to be extremely skilled in visually judging the rollability of the cut, its velocity, and the distance to be travelled, and then reducing the cut's speed to the desired retarder-leaving velocity. He had to make these judgments at the rate of seven to eight cars per minute.

Automatic retarder systems consist of two principal elements—control and prediction. The control elements consist of retarders and associated equipment required to bring the actual speed of a cut down to the desired leaving speed.

The prediction elements con-

*For both these writeups we are indebted to *P. J. Hermann*, the able and energetic Secretary of the MSC.

sist of a car rollability test measuring section ahead of the retarder, distance-to-go equipment, and an analog computer. As the car moves toward the last point of retardation, the rolling resistance of the car is measured in the test section, distance-to-go and preset information is fed to the computer, which in turn solves an equation of motion to obtain the desired release speed from the last point of retardation. The percentage of stalls and the spread in coupling speeds above and below the desired speed can be attributed largely to the shortcomings in the prediction elements of the earlier systems.

The newest and most precise automatic retardation equipment in actual operation is the Class-Matic equipment installed in the New York Central's Robert R. Young Yard located in Elkhart, Indiana. The yard, put in service in January 1958, consists of 72 classification tracks, 8 group retarders, and a four-section hump retarder. The height of the hump is 22 feet and the longest classification tracks have a capacity of 68 cars.

Mr. Frielinghaus presented slides and a detailed description of the operation of the yard, the computations necessary, and the analog computer circuits used, but as this is a special-purpose application, only general details are covered here.

The retarder control is a closed-loop system which continually compares the computed release velocity with the actual speed of the cut as measured with a doppler radar, and sets the pressure of the retarder so that the cut is brought down to the computed release velocity within the length of the retarder.

As the first truck of the cut enters the retarder, it receives a retarding force, which is augmented as the second truck of the cut enters the retarder. The deceleration of the cut under retardation is rapid until the velocity of the cut approaches the desired release velocity. At this time the retarder pressure is gradually reduced as a result of the feedback of radar deceleration information. As the velocity of the cut reaches the desired leaving velocity, the retarder is fully released, causing the cut to accelerate slightly due to the grade in the retarder. From this point on, minor retarder pressure is caused to cycle on and off, holding the velocity of the cut to small oscillations whose maxima lie slightly above and below the desired release velocity as the cut exits from the retarder.

A very important feature—the hump and group cabinets are equipped with elaborate automatic check circuits. At any time when a computer cabinet is not controlling a cut, it is given an artificial test problem whose answer must check within certain limits. Also, the retarder control equipment is fed a calibrated audio signal in lieu of the radar doppler signal and is checked for correct operation. At the same time all the field transducers associated with the particular cabinet are given a static check. As a car enters the particular region and the equipment functions actively, the sequencing of all operations is checked against a preset pattern. If at any time during either the static or dynamic check of the equipment a fault should occur, the retarder operator is notified through a fault alarm and lights indicate to him which retarder to manually control until the fault can be corrected.

The plot of control error of 1200 single and double car cuts under service conditions having release velocities of from 5 to 20 mph shows that over 92% of the cuts were controlled by the retarders to within 0.2 mph. It is probably amazing that such crude vehicles as freight cars, weighing up to 100 tons each, can be retarded to a quarter or less of their entering speed and controlled to such accuracies.

Because prediction is much more difficult than control, stopwatch measurements made of coupling speeds at the Robert R. Young Yard showed greater variations. Of 190 cuts, 2.1% coupled between 6 and 7 mph, which is too fast, 83.5% coupled between 1 and 6 mph, and 13.4% of the cuts stalled short of coupling.

The hump retarder computer system consists of 5 operational amplifiers for computing rollability and leaving velocity, and 3 operational amplifiers for holding the leaving information and one amplifier as a cut velocity differentiator for use in retarder control.

This equipment must operate continuously 24 hours a day, 7 days a week, with an absolute minimum outage time. Any fault or failure in any portion of the equipment must be self-indicating, and must be constructed so that it is readily replaceable since this equipment is serviced by non-technical maintenance personnel.

Red-base 10,000-hour tubes are used throughout the system, with the exception of power-supply regulator tubes, photocell tubes, and the klystrons used in the doppler radar. All units are of the plug-in construction, which allows complete change-out of any faulty unit. Very elaborate check, indication, and test facilities are built into the equipment to quickly pinpoint faults. A test rack is included with the system which has the facilities for dynamically checking and trouble-shooting every type of plug-in unit.

By the end of January 1959 this control system had completed 10,000 hours of continuous operation while being maintained by union maintenance personnel who have only a minimum knowledge of electrical principles. The system contains over 2500 tubes, of which 40% are associated with the analog computers. Since the installation of the equipment there have been only 46 tube failures, or less than 2% in 10,000 hours of operation. The 120 choppers used in the stabilizing circuits of the operational amplifiers have given little cause for trouble, and only in the past few months have required contact adjustment. In the computing networks, only one pot and one precision resistor have opened up. The radar equipment, which is mounted between the rails and is subjected to a high level of vibration, has operated continuously over an ambient temperature range from $-20°F$ to $+100°F$ without a single component or tube failure.

It is felt that the extra price paid for the high-quality engineering design and the quality of the computer components (supplied by Electronic Associates) has paid for itself many times over by keeping "out of service" time to an absolute minimum, and not requiring specialized technical maintenance personnel.

MIDWESTERN SIMULATION COUNCIL OF 6 APRIL ON SIMULATION OF AIRCRAFT AND MISSILES

About 58 representatives of 24 organizations attended the 6th April meeting of the Midwestern Simulation Council held at General Electric Company's plant in Evendale, Ohio to discuss "Simulation of Aircraft and Missiles."

Vern Larrowe, Chairman of the Steering Committee of the MSC, introduced *Max Sayler* (G-E, Flight

Propulsion Laboratories Dept.), host for the meeting; Max in turn introduced *Will Becraft*, Manager of Analytical Engineering in the Controls Section, Flight Propulsion Lab. Will extended a sincere welcome on behalf of "the high team bosses" who, he said, favor participation in professional societies by their people and were pleased to be able to host such a meeting. Then by way of introducing his company, Will showed slides of the G-E organization and equipment and said that locally there were analog people in three of the departments—Flight Propulsion Laboratory, Jet Engine, and Aircraft Nuclear Propulsion.

The computing equipment available is distributed as follows:

	FPLD
Digital	IBM 704
Analog	480 Amplifiers
Applications	Controls Lab Simulator
	JED
Digital	IBM 650 (Accounting)
Analog	170 Amplifiers
Applications	Controls Analysis Systems Analysis
	ANPD
Digital	IBM 704
Analog	400 Amplifiers
Applications	Controls Analysis Systems Analysis

After this welcome and introduction Max introduced Jim Elgin (G-E) to speak on "Computer Study of Recoverable Boost Propulsion Systems."

Elgin on Propulsion Systems

Referring to long-range rocket-powered missiles, Jim pointed out that the first stage of such a vehicle travels through the relatively dense atmosphere at low altitudes, having to overcome aerodynamic drag forces as well as gravitational forces. All fuel *and* oxidizer required for the job are carried on board at the expense of payload. Having served its purpose, the first stage is then dropped in someone's back yard to become a plaything for the children.

The G-E Advanced Marketing Operation of the FPLD has been interested for some time in the concept of replacing this first-stage rocket with a jet-engine-powered booster. Such a first stage could take advantage of the fact that the first phase of the flight is through an oxygen-containing medium and no oxidizing agent must

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The MC-5800 provides FASTER answers

1. Selection of real-time, expanded-time or high-speed compressed-time without reprogramming.

2. Real-time precision at speeds to 60 solutions/sec.

3. Dynamic memory with time-base accuracy of ±10 μsec provides automatic parameter searching by iteration—an exclusive capability.

4. It programs 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relay amplifiers, and 6 servos from one 2128-hole patchboard.

5. Unique automatic problem check checks problem-board patching in seconds and can record errors.

6. Exclusive electronic generators of the function of two-or-more variables may be programmed at patchboard in same time required for setup of single-variable generators.

7. Complete control of all amplifiers, multipliers, dividers, and non-linear equipment at patchboard.

8. Quick overload recovery in less than 1 sec.

9. It is the only computer offering card-programmed diode function generators.

The MC-5800 performs MORE ACCURATELY

10. Amplifiers provide lowest noise level output—less than one millivolt at unity gain.

11. Greatest distortion-free amplifier output—30 mils at ± 120 V—only 12 mils quiescent drain.

12. Lowest amplifier grid-current $< 10^{-9}$ ampere.

13. Stable amplifier operation over the entire feedback range from zero to infinity.

14. Drift < 50 μv in 8 hours in summing mode.

15. Amplifier frequency response—flat to 10,000 cps and only 3 db down at 28 kc.

16. Only diode function generators utilizing resistors, potentiometers, and diodes of equal quality to those in computing networks.

17. Only diode function generators with individual hi-lo gain positions for *each* segment.

18. Lowest function generator drift < 5 mv/8 hrs.

19. Highest servo multiplier accuracy, ±0.008%.

20. Only fully shielded patch *bay* and patchboard.

21. All contacts in patching system gold-plated.

22. Highest performance electronic multiplier—flat to 10,000 cps and only 3 db down at 20 kc.

23. Only servo multipliers and resolvers with zero backlash gearing—maximum one part in 36,000.

24. DC tachometer feedback on all servos.

25. Dynamic servo error—less than 50 mv at one cps.

26. Lowest step-function overshoot—less than 1%.

27. EVERY SPECIFICATION IS GUARANTEED TO BE TRUE PERFORMANCE STANDARD—IN SUSTAINED OPERATION.

28. Highest sin-cos resolver accuracy ±0.03% peak-to-peak.

29. Power supplies eliminated from console—lowest, most stable operating temperatures—rise < 3°C.

30. Passive networks stabilized at < 1°C above room-ambient—no oven required.

31. Servo-set pots can be set to 2 parts in 10,000.

32. Accuracy of computing networks at least 0.01%.

33. Lowest computer cross-talk—rejection greater than 2,000 to 1.

The MC-5800 can be operated at LESS COST

34. Greatest available problem capacity per dollar—by 20%.

35. Least cost for future expansion.

36. Output tube filaments operate with DC bias for maximum life.

37. Centralized overload indication for quicker trouble-shooting.

38. Only computer with hermetically sealed transformers.

39. Choppers employ double-contacts in parallel for maximum life.

40. Plug-in relays and step switches throughout for least down time.

41. Plug-in dynamic components ease maintenance.

42. Quickest trouble-shooting by automatic problem check.

43. Costliest and best patching system for lowest programming cost thru maximum reliability of patchcord connections.

44. Choppers de-energized when computer in standby for max. life.

45. Separate power-supply venting minimizes room heat load.

46. Exclusive equipment-door packaging for free access and quick maintenance *without* shutdown.

47. Insulated patchboard prevents costly shorting accidents.

48. Sealed servo gear boxes for maximum reliability.

49. Fully transistorized ADRAC system with plug-in logic modules.

50. Available on lease basis as well as for purchase.

The MC-5800 can SOLVE MORE OF YOUR PROBLEMS

51. Exclusive dynamic memory makes automatic iterative solution of statistical or optimization problems a reality.

52. Dynamic memory + high-speed quick-reset rep-op provide practical approach to solution of simultaneous partial differential equations.

53. Exclusive bi-variable function generators can also be used as amplifiers, multipliers, or generators of single-variable functions.

54. More computer capacity per dollar means more solutions.

55. Solution of problems with up to 15 amplifiers in closed loops.

56. Starting with as few as ten amplifiers, at a cost of little more than the cheapest available computer, you can build to a complete computing center of unsurpassed performance.

57. Add-on capacity up to 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relays with amplifiers, 4 bi-variable function generators, 6 servos, 8 function switches—all field-expandable without mechanical rework or rewiring.

58. Add-on features include automatic problem check, integrator rate test, high-speed repetitive operation, dynamic memory, expanded-time base, compressed-time base, servo-set potentiometers, and ADRAC (Automatic Digital Recording and Control) system—all field expandable without mechanical rework or rewiring.

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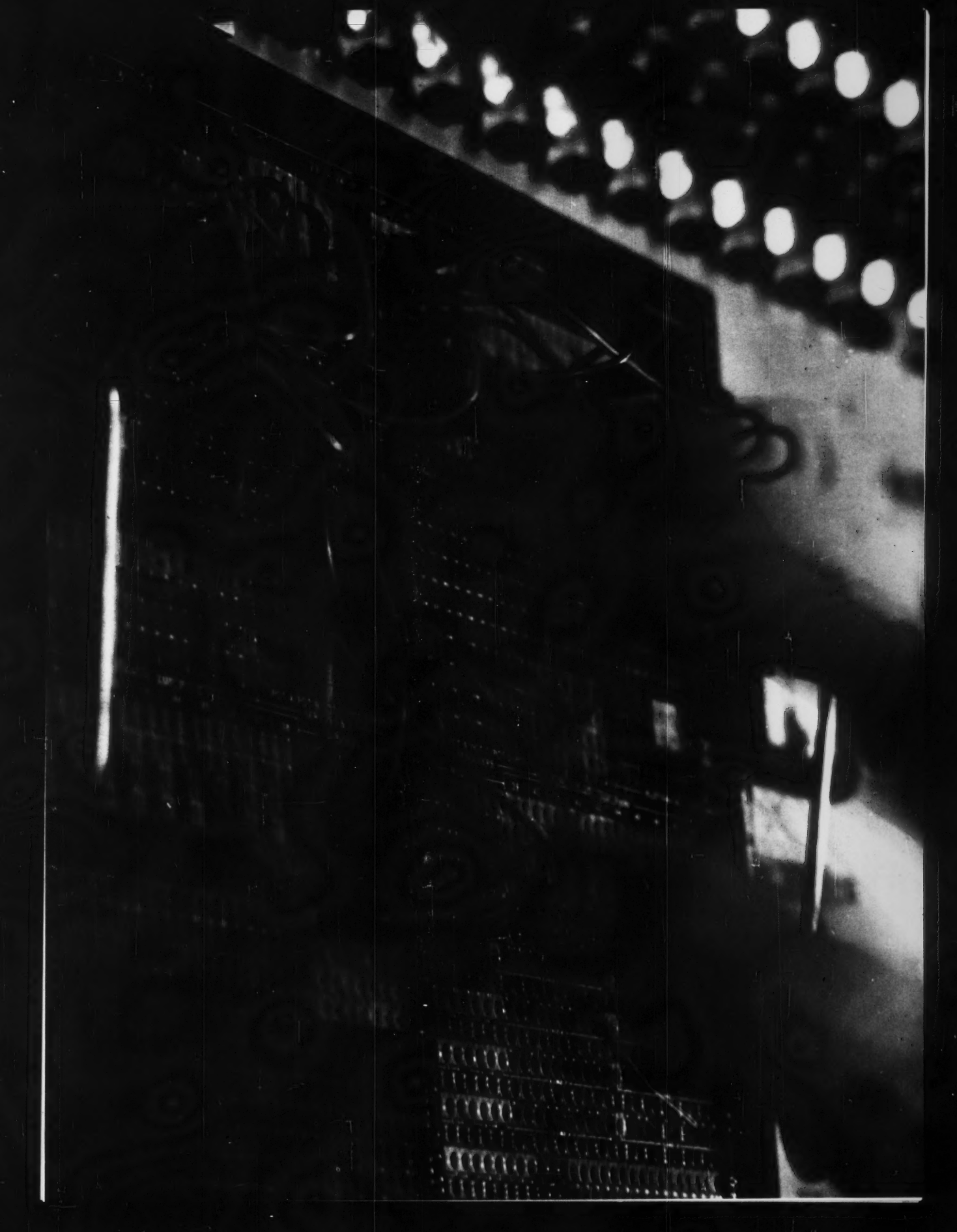

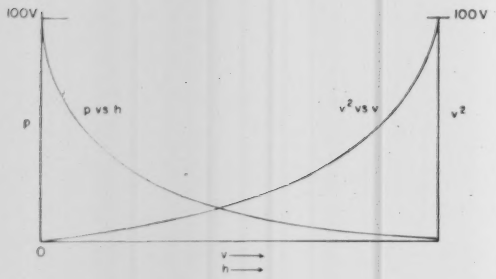

Fig. 1. Product of terms ρ and v^2 is always small.

be carried on board. To be even more competitive with rockets, this stage—as envisioned—would also be retrievable for re-use.

Pursuing the idea further, Marketing Operation requested the Analog Computations and Transient Analysis group of FPLD to prepare an analog-computer model of an air-breathing booster and investigate the effects of various design parameters on system performance.

System performance was studied over a flight envelope extending from a stationary position at sea level to high supersonic speeds at extreme altitude. The effects of three parameters were considered.

1. Thrust-to-weight ratio of the aircraft
2. Wing loading
3. The flight path taken by the vehicle

This led to some difficulties, the main source of which can be traced to the multiplier performing the multiplication $\rho \times v^2$. The term v^2 is a quantity that rises exponentially during a flight. On the other hand, ρ decays exponentially, and rapidly at that, as altitude increases. Since altitude and velocity increased more or less together, the multiplier saw a situation like that shown in Fig. 1. Obviously the product $\rho\ v^2$ was always a small voltage. Amplifying this sufficiently to make it compatible with other signal levels resulted in such a magnification of noise and system non-repeatability that flights would hit the moon one day and China the next—neither of which was their destination.

The next approach was to modify the lift and drag equations, but the mechanization of the new equations exhibited similar characteristics.

Then, said Jim, a powerful tool included in the jet-engine simulator was called into play: the map reader. These have proved valuable in representing three-dimensional functions of unknown mathematical relation (like engine compressor maps and turbine maps) many times in the past. In this case, however, the map reader was used to represent a very simple, known relationship:

$$q = \tfrac{1}{2}\,\rho\,v^2 = f(M, h).$$

A map could be drawn of "q" as a function of M and h. Since the output scale factor of the map reader is completely independent of the input scale factors, the output function could be scaled to 100v with no high-gain channels needed, and the resulting system, involving 61 amplifiers, 19 multiplicors, 12 D.F.G.'s, 2 map readers, 18 x-t recording channels, and 2 xy plotters, had low noise and excellent repeatability.

A second major problem which Jim described was developing a flight control. All trajectory control was achieved through variations in angle of attack. But for the phases described in terms of constant "g" one type of control is needed: for those in which Mach number must be controlled as a function of altitude, another is required. For a given airframe engine combination, the gains and dynamics between angle of attack and Mach number change considerably from sea level, M = 0 to high Mach; high altitude flight conditions. And furthermore, the airframe and engine combinations were, of course, changed periodically during the study.

It was therefore necessary to compute the trajectory in segments, which was accomplished by relay switching.

Continuous data were taken on multi-channel recorders and xy plotters during the runs to record instantaneous values of Mach number, altitude, angle of attack, flight path angle, fuel burned, range, and other pertinent performance data. One hundred and sixty-two runs were made in the horizontal take-off phase alone, while the thrust to weight and the weight to wing-loading ratios and trajectories were varied.

Armed with this information, Marketing Operation group was able to evaluate the effect of these independent variables on system performance. Conditions during the zoom phase were of primary importance. The optimum airframe-trajectory combination is one that permits a second-state launch at the highest Mach number with a good launch angle, after having burned minimum fuel.

Cacioppo on Human Factors

After Jim's talk Max introduced Dr. A. J. "Tony" Cacioppo (Goodyear Aircraft Corp., Akron 15, Ohio), who prefaced his talk on "Human Factors in Aircraft Control" with a credit to the simulation people present, saying it was appropriate that they know that he could not have been there to discuss his subject if it were not for their contributions. "We of the Behavior Sciences are first-class thieves," he said. "And we will utilize any technique that will give us better understanding of human behavior. We realize that all the sciences contribute to our field, and we hope that ultimately we will be able to provide an equal amount of information to them."

"In Human Factors we attempt to apply the Behavior Science principles to the analysis of man-machine systems. As a discipline, Human Factors developed during the second World War. Most of the activity centered about static systems—the design of better seats, better knobs, etc. Five or six years ago, a group of us took a look at the direction in which our field was going and decided we were not contributing as we should. To assess our position we began contacting more and more persons, especially in simulation." Now Tony thinks that considerable progress has been made in the past few years.

If you look at Human Factors in terms of the techniques or methods available for assessment of the dynamic characteristics of the human operator, it is clear that a requirement for future success is the development of nonlinear mathematics which will permit us to go from the operator directly to the equations which describe and define his characteristics.

"I have discounted, and I think there are certain of my colleagues who agree with me, the use of analytic techniques for the analysis and description of human operator performance," Tony said. "The reason for this is the assumption of linearity. If anything or any system is nonlinear, believe me it's humans!"

Digital systems were considered for

CIRCLE 73 ON READER-SERVICE CARD

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An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

Error-canceling Technique Reduces Integrator Drift

Offset Cancels Grid Current In Low-drift Amplifier

Two major sources of error in integrating operations are amplifier offset and input grid current. Both produce an error that increases steadily with time during the computing period. In a unity integrator with a 1μf capacitor, every microvolt of offset creates an error that increases 1μv per second. Each micromicroamp of grid current will produce exactly the same error. Because grid current flows in a known direction at a fairly constant rate, it has always been theoretically possible to cancel grid current error by deliberately offsetting the amplifier an equivalent amount in the opposite direction. Heretofore, this technique has been impractical because no available amplifier was sufficiently drift-free to maintain the correct amount of offset. With the development of an EASE amplifier that normally drifts only 20μv per week, the technique has become feasible.

Input grid current in EASE 1148 amplifiers ranges from 10 to 100μμa with a typical value of about 30μμa. Variation over a one-hour period is estimated to be no greater than 1μμa under normal conditions. To compensate for this grid current, offset may be adjusted over the range of 10 to 100μv. Variation in offset is typically 20μv per week. In one-hour period we may expect drift of 1 to 2μv.

Under these conditions you can see that it may be possible to hold integrating error from these sources to the range of 1 to 3μv/sec over a one-hour period. This would be a reduction in error of one order of magnitude.

How It's Done

The balancing circuit employed is diagrammed in Figure 1. The integrator circuit should be patched-in using the same input and feedback components that will be used in the actual computing run. Inputs are grounded, the output connected to the console voltmeter through two X20 summers and the integrator started on a computing run from an initial condition of zero. Then, the balancing control is adjusted until the meter needle stops moving. An error of 10μv/sec (referred to integrator output) appears as a visible motion of the needle.

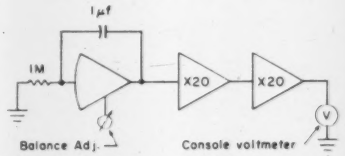
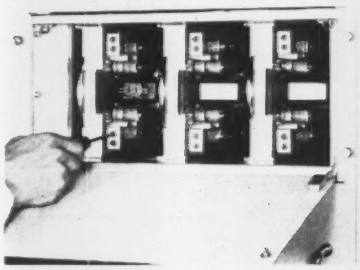


Figure 1. Circuit for balancing offset against grid current. Console voltmeter has a sensitivity of 10mv per division, thus reading 25μv per division when referred to integrator output.

Errors of a few microvolts per second can be detected by pausing a moment to observe the change in needle position.

The balancing circuit has been especially designed so that any adjustment causes the amplifier output to respond immediately and without overshoot and wobble. In other words, the output follows the adjustment "smoothly." The random fluctuations in offset that occur while the adjustment is under way are only a few microvolts in amplitude. The adjustment is fine enough to reduce error to 2 or 3μv/sec. With ordinary skill an integrator can be adjusted in a minute or two. Supposing error were to increase to 5μv/sec in the course of an hour, we would still be able to make 20-minute computing runs with a final error of only .003% of full scale due to offset and grid current.



To make balance adjustment the operator lowers a hinged front panel, revealing twelve amplifier channels and an adjustment point for each.

The estimate of error no greater than 5μv/sec during a one-hour period is based on a small sample of 1148 amplifiers tested. EASE engineers are now testing a statistically significant number of amplifiers and watching the variation in error over a long-term period. We will report the results of this study when concluded.

When the Technique Is Most Valuable

It is evident that this technique offers a significant improvement in accuracy when the integrating period is quite long. Another circumstance in which it may prove valuable occurs when the integrator output voltage is expected to hover near ground. This is because errors due to offset or grid current are always a percentage of full scale. In the vicinity of ground a small percentage of full scale may be a large percentage of input value. On the other hand, the other major error (error due to the fact that the feedback capacitor is not precisely 1μf) will always be a percentage of output value. Thus, as the output approaches ground, error due to offset and grid current becomes increasingly significant, while error due to the feedback capacitor becomes relatively less important.

Free Reprints of "Speaking With EASE" Series

The first seven in this series of informative ads are now available on request. Subjects discussed include:

- How to evaluate static accuracy.
- The effect of phase shift on dynamic accuracy.
- A comparison of electronic and servo techniques of performing non-linear operations.
- How to evaluate electronic multipliers.
- Utility of digital control systems.
- A comparison of different types of diode function generators.

C14

Beckman® / **EASE COMPUTERS**

Mfd. by Berkeley Division, Beckman Instruments, Inc. Richmond 3, California

CIRCLE 74 ON READER-SERVICE CARD

model building, but, in terms of one-to-one display of the human dynamics they were rejected because of the amount of equipment required and because of the lack of applicable knowledge of logical techniques.

Dr. Cacioppo then told of a study started by *Ray Mead* (now of McDonnell Aircraft) and *Nick Diamantides* (Goodyear, Akron, Ohio) with contributions by Tony and colleagues.

A simple aircraft simulator having a CRT display masked to look like a horizon gyro, a control column, and a pilot seat mounted on a single-degree-of-freedom platform was used, with the pilot acting essentially as a compensating network between a random noise input to the CRT and the simulator.

The first task was simply to "sweeten" the relationship by playing around with the spring system, damping, etc. until the operator could control the system with minimum effort. However, his output had a very decided predictable frequency of about 1.4 cps which was not present in the analog output. Once this was included in the simulation the computer was able to replicate the human imperfectly, but fairly well.

The simulation was sufficiently satisfactory (See Fig. 2) so that pilots who were fairly well skilled were able to fly the craft. Furthermore, at the discretion of the experimenter it was possible to change control from the human to the analog without the pilot's knowledge, in which case a skilled pilot would persist in a flight mode for several minutes without realizing that he no longer had control. The reason is that the analog doesn't make mistakes, but the human operator does. Before long he realizes that something's the matter: his errors are not reflected in the control of the vehicle.

As a behavior man Tony was interested in individual differences, so he decided to look at three classes of subjects—a pilot with 3 or 4,000 hours of flight, a pilot who flies a light plane, and a person who has never had his hand on a control stick.

They found that the highly skilled pilot used the least gain, whereas the inexperienced pilot used considerable: he put a lot of energy and effort into the control.

The highly skilled pilot tended to use more dither (the 1.4-cps motion), the naive person used very little.

Any operator makes use of the information provided by his CRT in terms of display position plus the two time derivatives, rate and acceleration. The inexperienced subject uses position information much more than two derivatives. Rate is used more by the semi-skilled pilot, and the really skilled pilot works with high-derivative (acceleration) information.

At present Tony's group is much interested in the perceptual block, that is, how the brain acts on information. The approach involves cross-correlation techniques, and so far the results have been encouraging.

The human operator has a definite threshold for the input and feedback of information. Furthermore, he has a certain bandwidth characteristic which is less than three radians per second.

There is no transfer function which describes all the performance characteristics of every person. But in general a transfer function for a particular individual can be defined in terms of compensatory reaction time and neuro-muscular lags, which is sufficient in most cases to give an adequate simulation.

At the conclusion of his talk Tony called for questions.

Vern Larrowe (Willow Run Research Center, Ypsilanti, Mich.) said, "I was interested in the dither you were talking about. Do you suppose that the pilot is subconsciously trying to get the feel of the system by doing this?"

"Yes," Tony answered. "It is subconscious. And he does use it to get information."

Chuck Walli, (NAA, Columbus, Ohio) commented, "I think all the work that's been done in adaptive control systems has been very largely based on dither."*

"This is absolutely correct," Tony answered. We human factors people are slowly working ourselves out of a job, because as more sophisticated control systems are developed there will be less and less reason for human factors analysis. But we're agreeable!"

This ended the morning session. During the lunch hour the study groups convened, and in the afternoon there were two more presentations: "Optimum Mission Profile Simulation" by *C. R. Walli* and *W. C. Franke* (North American Aviation, Columbus, Ohio); and "Simulation for Guidance Systems" by *P. J. Hermann*, (Goodyear Aircraft Corp., Corp., Akron 15, Ohio).

Although both interesting and pertinent the first paper will not be reported here because it was a very detailed (both as to mathematics and analog mechanization) presentation of a specialized problem. P. J.'s paper will not be covered because it is beyond the other end of the spectrum. It is a well-written and informative, yet understandable, introduction to guidance systems in general, with emphasis on the advantages of simulation for studying them in particular. This paper, which we certainly hope P.J. can make available to all those having an interest or a "need to know" in this area, is strongly recommended to those with an interest in the general area of guidance.

*Just one type of adaptive control, Chuck. —Ed.

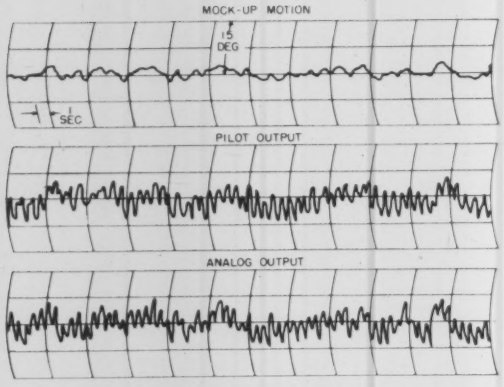


Fig. 2. Pilot output has "dither" frequency of 1.4 cps.

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Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For complete information on the LGP-30 write **ROYAL McBEE CORPORATION**, data processing division, Port Chester, New York

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CENTRAL STATES SIMULATION COUNCIL MEETING OF 11 MAY ON NON-LINEAR CONTROL SYSTEMS

Twenty-eight representatives of 11 organizations signed the register at Kansas State University for the 11 May meeting of the Central States Simulation Council. Subject of the meeting was "Non-linear Control Systems."

In spite of finding himself in the hospital the morning after the meeting *Charles Halijak*, Secretary of the CSC, sent us the following abstract of the papers presented within a reasonable time.

"Analog Computer Study of Pulse-Duration and Pulse-Frequency Modulated Control System." by Professor C. H. Thomas, Department of Electrical Engineering, University of Kansas.

In automatic temperature control systems, pulse-modulation of the valve positioner may be employed for the purpose of achieving positive action and reliable performance of the overall system. This paper presents the results of an analog computer study of such a system. The merits of the pulse-modulated control are discussed and means of stabilization are shown.

"A Position Servo with Multiplicative Velocity Feedback." by Mr. B. G. Strait, Instructor and Graduate Student, Department of Electrical Engineering, Kansas State University.

A non-linear servo derived from a velocity-feedback position servo is described. Its output is characterized by small time delay and no transient overshoot. The servo is very simple and the design can be applied readily to improve the performance of existing servos.

"Predicting Non-Linear Servo Oscillations from Harmonic Frequency Describing Functions." by Harvey J. Wertz and James L. Starr, Graduate Students, University of Kansas.

Heretofore, describing function analysis has assumed a sinusoidal input to the non-linear element. This paper illustrates that a more accurate prediction of system behavior can be obtained by assuming an input more characteristic of the actual oscillation involved. The method of analysis is demonstrated in two practical cases and checked experimentally by simulation on an electronic differential analyzer.

"Simplifying Non-linear Control Systems with the Quadratron." by Mr. William Comley, Douglas Aircraft Corporation.

The Quadratron is a squaring device using varistors. The basic inaccuracies and nonuniformities of the varistor have been almost entirely eliminated by using thermistor temperature compensation. Slight modifications of the auxiliary circuits enable realization of f (x^n) where $1/6 \leqslant n \leqslant 8$.

"Theory of the Single Input-Output Experiment." by Dr. Philip G. Kirmser, Department of Applied Mechanics, Kansas State University.

A theory is constructed which describes the response of a continuous non-linear system to an arbitrary input in terms of its responses to a finite number of test functions. The theory exhibits a generalization of the principles of superposition, the inherent complexity of non-linear problems, and a measure of the non-linearity of certain non-linear systems.

Feeling that the importance of the subject deserved fuller treatment than these abstracts, your Ed wrote each of the authors for further information. After reporting of the meeting had been delayed for three months, three of the authors had responded: Dr. Kirmser said he could not improve on Dr. Halijak's abstract, but that the presentation from notes created enough interest to encourage preparation of a manuscript for publication: James Starr sent in a very good summary, but it is too mathematically erudite for this *Newsletter;* and William Comley sent in an excellent sales pitch for the Douglas Quadratron.

Because we do not mind presenting sales pitches in the Newsletter *if they give information which may be interesting or useful to simulation people*, we herewith pass on some of this one.

Comley on Simplifying Non-linear Control Systems with the Quadratron

At a recent symposium on non-linear control systems, a number of prominent workers in the field unanimously expressed the opinion that the major stumbling blocks in the road to progress are: (1) lack of adequate mathematical theory, and (2) economic factors associated with the proper mechanization of large-scale non-linear systems. As to the second factor, we are all aware of the high cost of representing large numbers of non-linearities on the analog computer. We are also aware of that insidious law which seems to dictate that the equipment required for a given problem exceeds the amount on hand by a factor greater than one.

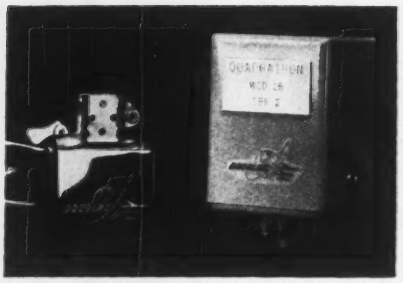


Fig. 3. The Quadratron.

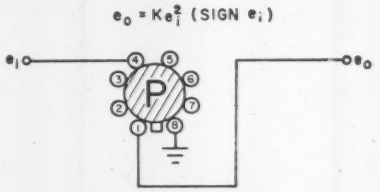


Fig. 4. Squaring function of Quadratron.

A method of simulating non-linearities which has been proposed from time to time to ameliorate these difficulties is one based on the non-linear properties of the varistor (i.e., non-linear resistor). However, due to its many sources of error the reception accorded this method has been less than overwhelming.

In 1954 Dr. *L. D. Kovach* and *William Comley* (both of Douglas Aircraft Co., El Segundo, Calif.) published a paper entitled "An Analog Multiplier Using Thyrite." As recently as nine months ago they saw a paper written by *A. A. Maslov* of the Moscow Academy of Sciences entitled "An Analog Multiplier Using Thyrite Resistors." They were intrigued by the similarity in titles, and subsequently learned that though the work described was based on their 1954 paper, the Russian paper also included some interesting improvements. This encouraged Kovach and Comley to continue their own work. The unit resulting from this work (Fig. 3) has been dubbed the "Quadratron" (from the Latin "quadrare" —to square—and "tron" as in electron), which has much wider application than just multiplication.

The Quadratron is a small passive device designed to make possible the inclusion of many non-linear terms in computer studies without any substantial increase in either computer cost or complexity. By proper design techniques, the many sources of error inherent in the varistor have either been eliminated or drastically reduced. The basic function of the Quadratron is shown in Fig. 4. The error of the squaring operation is less than 0.2% of full scale (i.e., of 200 volts).

Operational amplifiers and potentiometers are the only auxiliary equipment required. Being entirely passive, the Quadratron requires no sources of power other than the input signal itself. Among the classes of functions which may be obtained are the power functions and the transcendental functions including the trigonometric and hyperbolic. Other non-linear operations (multiplication, division, and vector addition) may be simplified; while the bandwidth is improved a hundredfold over electromechanical components.

Ordinarily, four function generators and one amplifier would be required to obtain the vector sum of three mutually perpendicular quantities; four Quadratrons and one amplifier can be used instead.

The Quadratron also provides a reliable method for linearizing certain transducers commonly used in control and instrumentation.

We Goofed!

Shortly after the Rand meeting of the Western Simulation Council (see September issue), *Hans Meissinger* of Hughes Aircraft gave us some figures which he had used in his talk to be sure they were given correctly in the *Newsletter*. Nevertheless, somehow, they were quoted wrongly, so we offer here the correct numbers.

"The approximate rate of IBM 709 versus REAC 400 should be quoted as $350 versus $50 *per hour* instead of *per diem* as stated in the *Newsletter*."

Our apologies to Hans and to our readers.

Information (Without Theory)

We have a welcome letter from *Robert H. Kohr* of General Motors which reads in part:

> In an attempt to raise our competence in scaling we prevailed upon Dr. *R. M. Howe* of the University of Michigan to lecture to us on the general scaling problem. As a result of Dr. Howe's efforts our scaling troubles have been materially lessened. In the interest of sharing this work with others, we have collected Dr. Howe's lectures into an internal publication (GMR 206, "Scaling for Electronic Differential Analyzers"), a copy of which is enclosed. I think that you will find that this report contains much new and valuable material, particularly the concept of scaling based on the consideration of component characteristics. If you feel that this publication would be of use to other people in the analog field, we would be pleased to offer it to them, through the *Newsletter*. Copies may be obtained by writing to me.

Mr. Kohr's address is Engineering Mechanics Dept., GM Research Laboratories, Warren, Mich.

* * *

Our friends at Mid-Cen—er, I mean Computer Systems, are still keeping us informed. Now they have announced incorporation of high-speed memory and automatic iteration capability in a general-purpose analog computer: "The new system (DYSTAC) synthesizes the traditional advantages of both analog and digital computers . . . Analog computers can now be effectively used for automatic iterative solutions of statistical problems; on-line computer control with sample-data inputs; utilization of numerical integration procedures; and generation of multiple-variable functions." Automatic optimization by least-mean squares; automatic solution of simultaneous second-order partial differential equations; and analysis of sample-data systems are now possible, they say.

* * *

Some people have complained of advertisements placed within the *Newsletter* section of this magazine. When these ads are alien to our interest these people may have a point; on the other hand some ads can be more pertinent than this sometimes impertinent *Newsletter*.

I have before me a series of ads by Beckman/Berkeley which certainly fall in the second category. They are billed as "an up-to-the-minute report on computer technology" and tackle such controversial subjects as "How to Judge Electronic Multipliers —And Why" (and some 30 other aspects of analog computers) in a clear and informative style with minimum apparent bias. It would seem that this kind of advertising should be encouraged.

He Went Thataway!

Robert L. Yeager, Chairman of the Eastern Simulation Council, up to

"General Sales Manager, Standard Products" of EAI.

* * *

George T. Jacobi, long-time participant in the activities of several of the Simulation Councils, to Assistant Director of Research, Electrical Engineering Division, Armour Research Foundation, Chicago, where he will guide the computer and control activities.

(Scientific and Sensual)

San Francisco in May for Computers and Companionship. C' est la vie!

Journal of the S C M A . . .
SOUTHERN CALIFORNIA METER ASSOCIATION

President: *Martin E. Kantor*
Vice-President: *J. Marvin Lange*
Secretary-Treasurer: *Glen C. Wilson*, 10219 *Orange Ave., South Gate, California*
Auditor: *Robert P. Ridout*
Program Chairman: *Arthur R. Alworth*

Industrial Flowmetering with Turbine Meters

BERNARD ARTZ, Fischer & Porter Co.

TURBINE-TYPE FLOWMETERS generally are axial-flow displacement-type pickups. They are essentially volumetric, with only slight deviations occuring due to some minute slip between the rotor blades and the fluid. Liquid enters the upstream connection (Fig. 1) and passes through the flow straighteners which remove effects of upstream piping. On the downstream edge of the flow straighteners a sharp-edged orifice causes the fluid to pass around the rotor in a turbulent condition. The orifice further reduces the effect of upstream piping and increases the linear range of the meter by increasing the degree of turbulence as the flow enters the metering area. The flow then passes downstream around the rotor assembly, causing the rotor to turn in direct proportion to volumetric flow.

As each blade passes underneath the coil, which is wound on a permanent-magnet core, a sinusodial wave is generated in the coil; hence, the number of pulses is directly proportional to volumetric flow rate. Generally the airborne unit is constructed in sizes varying from $\frac{1}{4}$" up to 8" or 10", which handle flow rates in the order of 10 gpm to 10,000 gpm. The most popular sizes are 3" and below. The entire flowmeter usually will be constructed of corrosion-resistant stainless steel; other materials also are available.

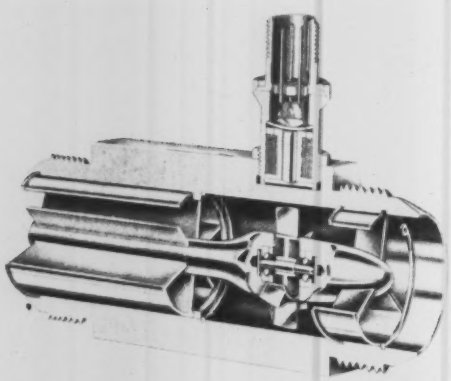


FIG. 1. Typical turbine flowmeter construction.* Vanes at left straighten incoming fluid; coil above rotor develops pulse each time a vane swings by below. Permanent magnet is core of coil.

Presentation of Data

As the electrical output frequency is directly proportional to volumetric flow rate, the simplest way of tabulating data is to plot a curve frequency vs flow. The shortcoming of this method is that the frequency-vs-flow curve cannot be read with the accuracy inherent in the meter.

A preferred method is to plot the *slope* of the frequency-vs-flow curve vs frequency (Fig. 2). The slope of the line is cps divided by gallons per minute; it is commonly referred to as the *flow coefficient* (K). K is in cycles per gallon and is plotted vs output frequency.

These meters are equally repeatable for flow in either direction; however, the coefficient obtained in one direction is usually several percentages removed from the coefficient obtained when calibrated in the other direction. Also, because the meter has straightening vanes only on one side of the rotor, when fluid is passed in the reverse direction, upstream piping effects do become apparent.

Various shaped curves for several viscosities indicate that the output is a function of volumetric flow

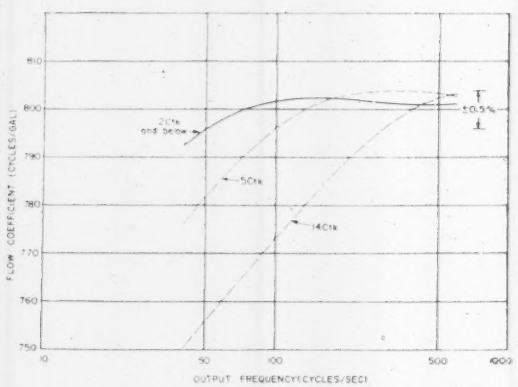


FIG. 2. Flow coefficient (K) plotted against output frequency for liquids having three different viscosities.

rate and viscosity; hence, turbine-meter data should include viscosity. Fig. 3 shows meter coefficient (K) plotted *vs* cps (F) over viscosity in centistokes (μ) which is normally referred to as the *viscose influence number* (N). This curve includes pertinent factors of the turbine meter. Each turbine meter has a continuous coefficient curve, or characteristic. Deviations from this curve mean that the meter is affected by outside forces either due to the magnetic attraction of the coil or the frictional forces in the bearing assembly. In the linear portion of the curve accuracies in the order of $\pm\frac{1}{2}\%$ of rate are obtained easily; in the non-linear portion accuracies still are substantially better than are normally considered desirable in industrial flow rate applications.

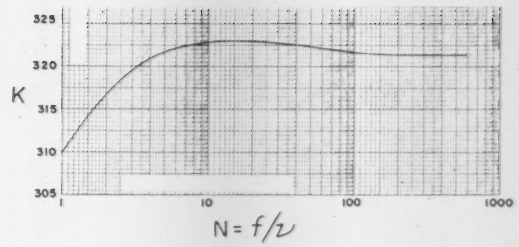


FIG. 3. Flow coefficient (K) plotted against output frequency (f) divided by viscosity in centistokes (ν). This characteristic (N) is furnished with flow pickup.

Readout Equipment

Generally the manufacturer will stamp the coefficient (N) on the turbine-meter body and furnish a calibration curve. This calibration curve is obtained by calibrating the turbine meter on a primary standard whose accuracy is approximately 0.1%. The coefficient stamped on the meter body is obtained by drawing a horizontal line on the calibration curve such that all points of the curve fall within 0.5% accuracy area. Consequently, if the meter coefficient is used throughout the range of the turbine meter, the data will be within 0.5%. However, if the actual calibration curve is used, accuracies well within 0.25% are obtained easily.

Digital-type readout devices are recommended to maintain the inherent accuracy and repeatability of a turbine meter. Most digital counting devices, EPUT counters, straight frequency counters and similar devices, have an accuracy of $\pm$ one count out of the total number of counts. If counting time is long enough to accumulate a substantial number of pulses (perhaps in the order of 5 seconds) the counting error becomes negligible. This type of a device is generally used for high-accuracy metering of steady-state flows, or as a totalizing device for integrating total flow over some period of time. A typical digital totalizer is shown in Fig. 4.

FIG. 4. Digital totalizer shows total flow over interval of time.

The digital display device can incorporate a specific-gravity adjustment and display mass rate of flow. The unit shown in Fig. 5 uses a manual adjustment; automatic specific-gravity adjustment devices also are available.

FIG. 5. Specific gravity is set on digital readout pot; flow readout is mass rate of flow.

The frequency output of the turbine meter can be recorded directly on high-speed recording devices such as oscillographs for metering transient flow. This recording is in frequency *vs* time, and data reduction can become laborious. Usually conversion of frequency output to d-c millivolt analog signals is preferred. A frequency-to-dc converter is available which is accurate, has a rapid rise time characteristic, and is expensive. It usually is used only when high accuracy and fast transient response is required. Less expensive indicator units not only give a d-c analog output but also indicate instantaneous flow rate.

December Meeting: Thursday, the 17th, 6:30 p.m., Rio Hondo Country Club, Downey, California.

Feature: Past Presidents Night.

Applications

Turbine-type flowmeters are being used successfully for flow rates varying from fractions of gallons per minute to tens of thousands of gallons per minute, with pressures up to 6,000-7,000 psi, and temperatures from $-400°$F to $+1,000°$F. They work satisfactorily with any reasonably clean fluid and have been used successfully in the following areas:

Component Testing: Testing aircraft and missile components involves wide temperature and pressure ranges; high-accuracy measurements are mandatory.

Blending: Accurate blending of two or more ingredients in either batch or continuous processes is accomplished easily by using relatively simple electronic control systems.

Custody Transfer: Metering liquids for billing purposes including petroleum products, chemical products, liquified gases, food products, etc.

Aircraft and Missile Fuels: The in-flight use of propellant fuels is critical; high accuracy and the ease of telemetering the data are important.

Cryogenic Liquids: The turbine meter has found widespread use in cryogenic fluids, including LOX, liquid nitrogen, liquid hydrogen, hydrogen peroxide.

Petroleum: The turbine meter is finding widespread use within refineries, in the finished product of the petroleum business, as well as applications to LACT systems and other oil-producing uses.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

SPECIFIC GRAVITY OF LIQUID IS CONTROLLED BY BUBBLER-TYPE DIFFERENTIAL-PRESSURE MEASUREMENT

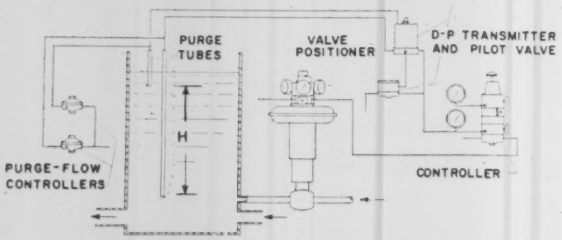
A simple way of controlling liquid specific gravity in an open tank is to let air bubble out at two different levels of the tank, and to feed the purge pressures to a differential-pressure transmitter. The output signal of the transmitter is piped to a pneumatic controller, which in turn sends a signal to a valve positioner. The positioner controls the feed of high-gravity material to adjust the sp. gr. of the solution.

If air is bubbled through the purge tubes at a constant flow rate, then the pressure at the output of the bubbler tube depends primarily on the density of the fluid. By using two bubbler tubes, the effect of level change in the tank is removed—that is, the differential pressure depends only on H and SG. Air flow is kept constant by simple constant-differential relays (Model 62V Purge-Flow Controllers), regardless of change in air-supply pressure. No supply-pressure regulators are required.

Flow rate of purge air affects only the speed with which system can measure a change in specific gravity. It has no relations to liquid density. Relationship between dip-tube spacing (H), specific gravity (SG) and differential pressure (ΔP) is:

$$\Delta P = H\ (SG_1 - SG_2)$$

where SG_1 is gravity of fluid in tank and SG_2 is gravity of purge medium (air). If H and SG_2 are constant, then P is a direct measure of SG_1, as desired. However, the scale is suppressed by the factor H (SG_2).



The Differential-Pressure Transmitter (Model 10B) uses a pneumatic null-balance system to measure and amplify differential pressures and to transmit an output signal to the controller. Transmitter pressure has a true linear relation to the differential measured; accuracy is 0.1% of full scale. Transmission of the signal is at high speed owing to use of booster Pilot Valve (Model 60N).

Controller (Model 55) is a stack-type control instrument, operating on the pneumatic force-balance principle, consisting of an integral control-point-setting regulator, reset unit, throttling unit (for proportional control), and a booster pilot valve (in this order, top to bottom). Where set point is to be varied from a remote location, a Model 50 Controller and a separate M/P (miniature-panel) control station are used.

The control valve is single-seated for tight shut-off, and equipped with a Model 73 valve positioner, because fine positioning is required for the minute changes of static pressure that result from changes in the specific gravity. Model 73, an integral type which works on the force-balance principle, is mounted on top of the diaphragm actuator.

Source: Moore Products Co., Philadelphia; also Bulletin 102.

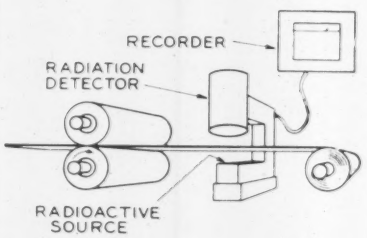
THICKNESS OF TRAVELING SHEET MATERIAL IS MEASURED BY BETA-RAY SOURCE

Measurement of thickness of paper, sheet metal, sheet plastic, coated fabrics, etc., while moving on the finishing machine is essential to keep control of the dimensional requirements of the product.

Thickness gages operating on principles utilizing beta-ray or gamma-ray radiation from radioactive isotopes, or x-rays, have the advantage of not contacting the material, and therefore leave no trace on it.

A representative installation (shown) uses a radioactive source and a radiation measuring head or detector between which the material passes. The absorption of the radiation emitted from the source is proportional to the mass density of the material (which under certain conditions is proportional to basis weight or thickness). The detector output is standardized and amplified to produce an electric signal sufficiently strong to operate a Dynamaster potentiometer indicator recorder.

Source unit and pickup are mounted on a rigid frame to maintain accurate alignment. The whole radiation unit can be moved by a servo motor to scan the width of the material.



In order to control the rolls, the rolls must be adjusted on the basis of an average, rather than an instantaneous, reading of thickness. Hence the controller, if used, must have an averaging circuit. The average is permitted to fluctuate within defined limits, with control action being proportional to the magnitude of variation outside these control limits.

Source: The Bristol Company, Waterbury, Conn.; also Bulletin P1245-A "Dynamaster Electronic Instruments."

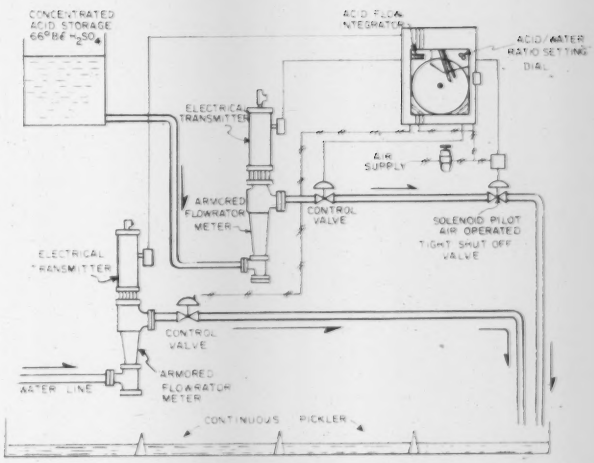
CONTINUOUS STRIP PICKLING WITH ACID CONTROL

Continuous cascade pickling (passing the steel strip through a series of tanks and controlling the addition of sulfuric acid in proportion to the rate at which it is being used up) has gained favor recently. Acid is added at the exit tank and the strip is moved in counterflow to the acid.

A system at Jones & Laughlin Aliquippa Works uses a ratio controller to proportion acid and water, measuring flow by Fischer & Porter armored "Flowrator" meters and using an air-actuated control valve as the final control element for the acid addition.

Electric transmitters (attached to the Flowrator meters) signal the flow rate of water and acid, respectively, to the ratio recording controller, which proportions the acid to the water. Before operating the equipment, the number of tons to be pickled per hour must be known to determine the correct amount of acid and water to be added. Water flow is controlled by a separate pneumatic controller in the same instrument case. The desired flow rate is set manually at the controller. A direct-reading dial in the recording ratio controller is set to obtain the required percentage acid solution (between 15 and 30%) for the tonnage of strip to be pickled per hour, based on 35 lb of 66°-Baumé-H_2SO_4 per ton.

To insure tight shut off, the acid line includes an air-operated valve with solenoid pilot; a limit switch in the controller actuates the solenoid when the signal from the water Flowrator indicates that the flow has fallen below a set minimum. The three-way solenoid valve then exhausts the air supply and shuts off the valve in the line tightly.



The acid control valve is made of iron with alloy 20 trim. The Flowrator in the acid line is all alloy 20.

The advantage of this continuous method lies in savings which can be obtained in the acid consumption and the high degree of uniformity in pickling.

Source: Fischer & Porter Co., Hatboro, Penna.; also W. H. Stuck, "Strip Pickling Requires Acid Control," *Instruments & Control Systems*, March 1955.

AUTOMATIC TURBINE SWITCHOVER VIA 3-WAY REGULATING VALVE GUARDS POWER STATION

Use of a small diaphragm-operated three-way valve in the supply line to a pilot controller can be a simple means of safeguarding a power station turbine against steam-pressure failure.

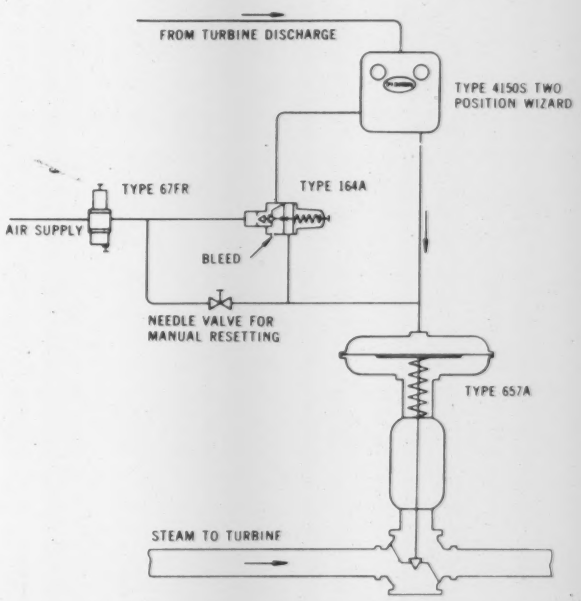
The main valve shown (maker's Type 657A) is in the steam line to an auxiliary turbine, and is normally held closed by the two-position, on-off, pilot-type controller (Type 4150S), whose air supply comes from a pressure regulator (Type 67FR) via the small 3-way valve (Type 164A). The system is shown in this normal condition, with the air supply reaching the two-position controller via the 3-way valve, needle valve closed, main valve closed, and auxiliary turbine inoperative.

When steam discharge pressure from the operating turbine falls below a preset point, however, the nozzle in the controller snaps open, and the air pressure on top of the diaphragm of the valve drops. This reduced pressure also reaches a chamber in the 3-way valve, permitting the spring in this valve to close the valve so that the air supply pressure cannot reach the controller, and bleeding this pressure off through the relay. The result is that the pressure on top of the main valve quickly falls to atmospheric, at which point the spring in the main control valve opens the valve, admitting auxiliary steam to the standby turbine, which takes over.

When it is desired to shut off the auxiliary turbine, the control valve to the auxiliary turbine is closed manually by opening the needle valve, which admits pressure to the top of the diaphragm and also switches the three-way valve to readmit air supply to the Wizard controller.

The control valve is single-seated to assure tight shut off.

Source: Fisher Governor Co., Marshalltown, Iowa.



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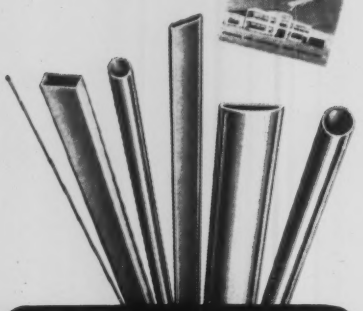

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new instruments

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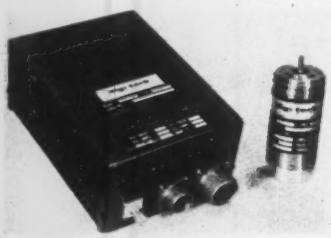
DIGITAL STEP MOTOR

New Digitork, instrument-size Digital Step Motor with solid-state control, features precise bi-directional

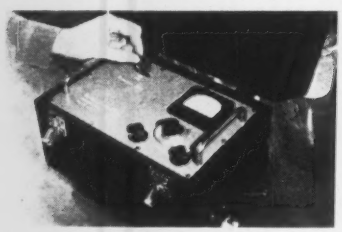


controlled step output for input signals up to 3 kc, high instantaneous response rates, high step resolution, and linear response. Rugged self-locking, stable, and non-oscillating motors provide excellent torque-to-speed characteristics with outputs ranging from one in-oz (for the instrument-size motors) to 100 in-lb (for a large industrial size), and with steps per revolution from 36 to 108. Rated for operation through a 24 to 250 volt d-c range. Reprints of paper presented at Control System Components Conference on request.—*Teller Co., P. O. Box 989, Butler, Penna.*

CIRCLE 183 ON READER-SERVICE CARD

CLEANLINESS TESTER

New Model CM-1 Cleanliness Tester, developed by the Graham Research Labs. of Jones & Laughlin Steel Corp., makes it possible to assign numerical values to surface cleanliness where

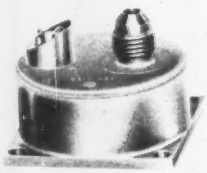


non-bonded soils are involved. A special densitometer-type instrument, it measures smut residue after pickling of steel, evaluates detergents and oils used on cold mills; annealing-furnace performance, etc. Accuracy of one part in a thousand is made possible by a ten-turn potentiometer. —*Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.*

CIRCLE 184 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

New miniature Pressure Transducer, Model 725, employs a unique bourdon-tube movement which withstands extreme vibration. Dynamic error band for all effects, including vibration, is only ±1.8% for sweep



or dwell vibration in the range of 20-2000 cps up to 35g. Available in 11 standard pressure ranges from 0-200 to 0-5000 psig, and with resistance elements from 1,000 to 10,000 ohms. Power rating of the unit is 1.0 watt. 2-page bulletin contains details. —*Bourns, Inc., P. O. Box 2112, Riverside, Calif.*

CIRCLE 185 ON READER-SERVICE CARD

24-HOUR CLOCK

New Model 4000 in a series of custom-designed 24-hour clocks, with split seconds graduated to 0.02, features the unique Haydon PlanetGear

drive which cannot skip or miss a number because the gears are always in mesh. Timing motors of the miniature series are available in 115 v; 50, 60, 400 and 500 cps. Numbers are ⅜" high to MIL-S-33558 white on black or black on white.—*Haydon Instrument Co., Box 991, Waterbury, Conn.*

CIRCLE 186 ON READER-SERVICE CARD

DIGITAL INCREMAGS

New Incremags are miniature digital components; perform counting-dividing functions otherwise requiring a battery of binary-type units. Have a variable counting rate of up to

100,000 pps and accept random or uniformly spaced inputs. Outputs in ratios of 1/1, 1/10, 1/100, 1/1000 1/10,000 and 1/100,000. A mixture of counts (up to 16 per stage) other than decade is available.—*General Time Corp., Research Lab., 107 Lafayette St., New York 13, N. Y.*

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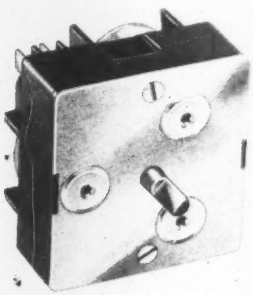
CYCLE TIMER

New Cycle Timer, Series AC-42, is a totally-enclosed, motor-driven switching device which repeats a set cycle or sequence of switching oper-

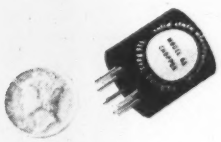


ations as long as the motor circuit is energized. 18 intervals from 15 sec to 24 hrs are available.—*Haydon Div., General Time Corp., 245 East Elm St., Torrington, Conn.*

CIRCLE 188 ON READER-SERVICE CARD

TRANSISTORIZED CHOPPER

New Model 65 transistorized plugin chopper or modulator incorporates a transformer-coupled isolating network to permit operation from 400-cps power line driver or from a drive



source common to the d-c voltage being chopped. Operates over frequencies from 275 to 30,000 cps to chop voltages from a millivolt to 5 v. Withstand 500 g shock for 11 msec, 30g vibration from 0 to 2000 cps, and acceleration to 700 g. *Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif.*

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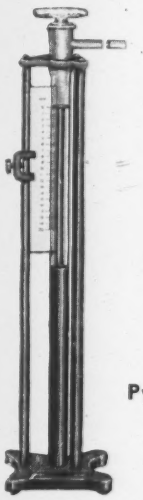

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Range: 0.2 mm To 20 mm of Hg

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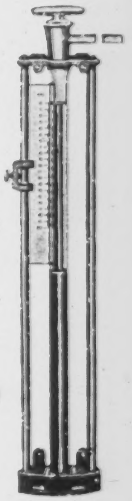

No. 1451 H.
Wall Mounting

The Welch-Dubrovin Gauges are made in two basic types. One 9 times and the other 6 times as sensitive as a mercury manometer. Because of this "magnifying factor," the gauge is as sensitive as a manometer which uses a liquid of low density, but has the advantage of using mercury which dissolves very few organic or inorganic vapors and which requires no conversion factor. Unlike mechanical or optical magnifying devices, any small errors due to capillarity, adhesion, etc., are not magnified. The smallest division on the 9-to-1 type is 0.2 mm and on the 6-to-1 type is 0.5 mm of Hg. Fractions of these values may be estimated. Both types are available with Pyrex-brand or soft glass in either table or wall mounting.

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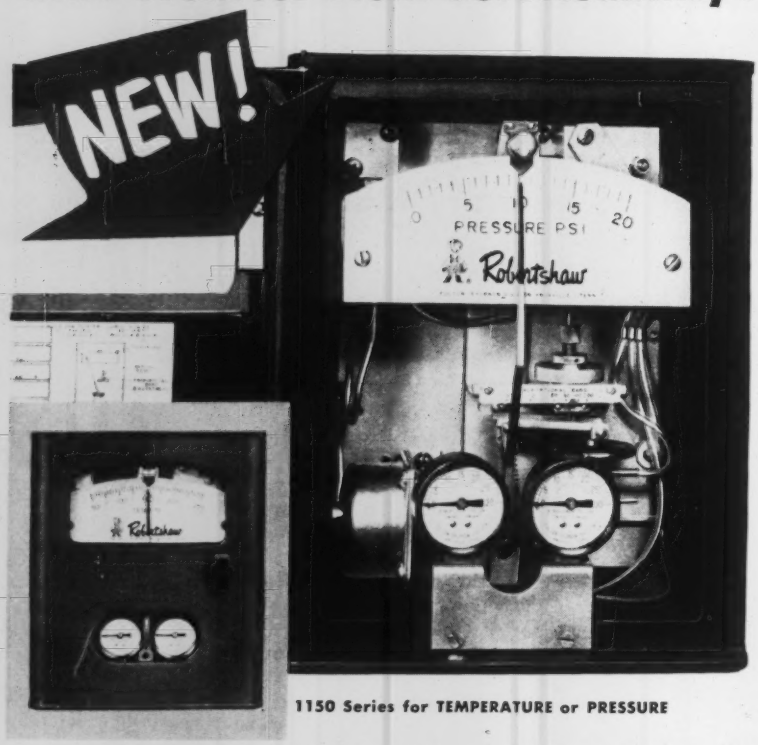

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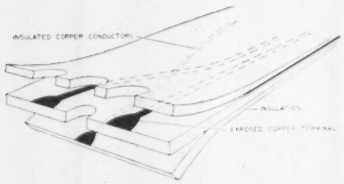
New custom-designed flexible Etched Circuitry, can be produced in straight cables or complex wiring patterns, in single or multi-layer constructions. Circuits can be formed in



an infinite variety of metallic etched patterns, sandwiched between two or more layers of a suitable plastic, depending on the application. Available in production quantities.—*International Resistance Co., 401 North Broad St., Phila. 8, Pa.*

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New series of desiccant Dryers for drying gases at elevated pressures (1000 to 6000 psig), can handle air,

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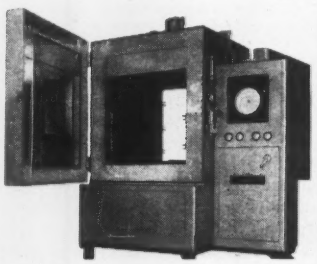
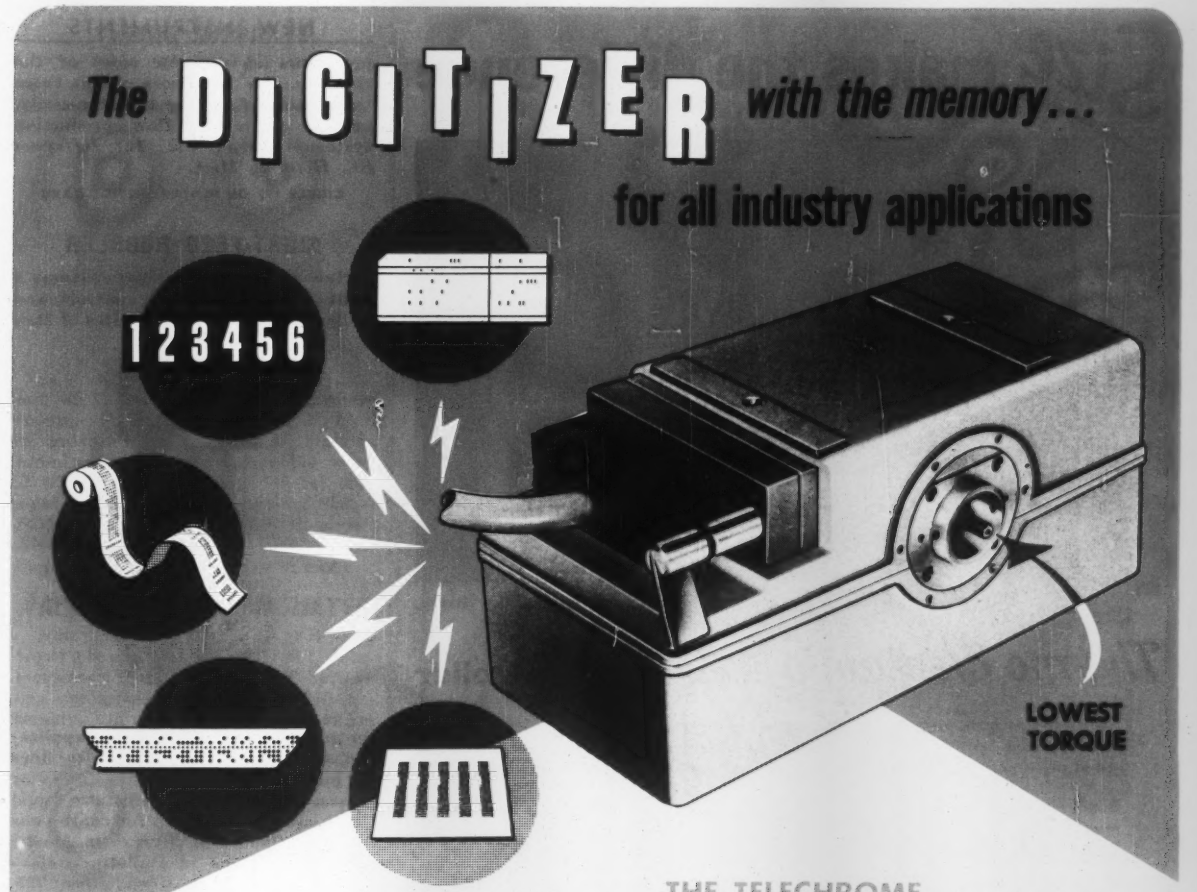
TEST CHAMBER

New FB-30 series Temperature Test Chamber features two full open-





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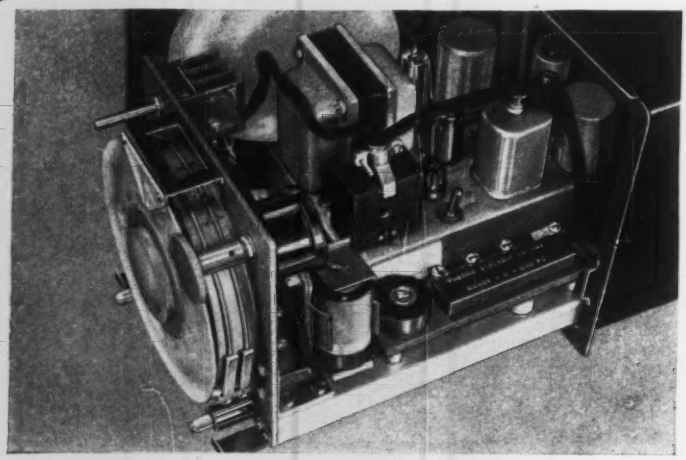

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15.8″ scale has large, easy-to-read numerals.

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ing doors on opposite sides of the chamber. The two doors permit twice the volume of testing simultaneously, and a continuous flow production system.—*Conrad, Inc.*, 141 *Jefferson St., Holland, Mich.*

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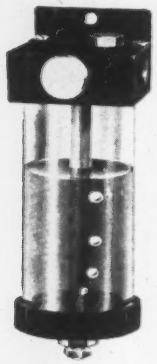
SIGHT-FEED BUBBLER

New Sight-Feed Bubbler features a built-in check valve and controls, and indicates relatively small rates of flow



in gas and air lines. Typical applications include bleeding air into lines to purge them of corrosive fumes or gases, and use with hydrostatic liquid level gauges hooked up for continuous gaging. Choice of Pyrex or plastic cylinder. Details in Bulletin 3285.—*King Engineering Corp., Box 725, Ann Arbor, Mich.*

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New gold-gallium (up to 2½% gallium) and gold-antimony (up to 0.7% antimony) alloys for use in semiconductors are available in wire (0.0005″ min. dia), sheet (0.001″ min. thickness) and in special shapes to customers' specifications.—*J. M. Ney Co., Maplewood Ave., Bloomfield, Conn.*

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PUSH-TYPE HOSE FITTING

New "Push-lok" line of Fittings and industrial hose for air, water, oil, and fuel service at pressures under 250 psig is offered with seven different connecting ends: male pipe thread; Triple-lok end to connect 37° flared tube; 45° cone to connect 45° flared tube; swivel nut to mate with Triple-lok 37° cone; swivel nut to mate with 45° cone; inverted 45° flare seat; and inverted swivel nut to mate with inverted 45° flare fitting. Catalog 4482 gives details.—*Parker Fittings & Hose Div., Parker-Hannifin Corp.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

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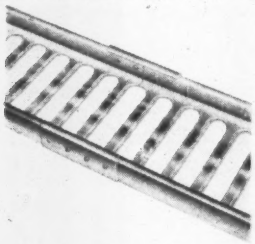
TUBING SUPPORTS

New Type "E" Tray for continuous support of instrument piping, multi-tube and control cables, is stronger, less expensive, and permits dropping



out of tubing and cables anywhere in run. Furnished 1½" and 3" high in galvanized steel, and 3" high in aluminum. Is interchangeable with P-W's ladder, expanded metal and solid trays. Details in Catalog 858.—*P-W Industries, Inc.*, 11200 *Roosevelt Blvd., Phila.* 15, *Pa.*

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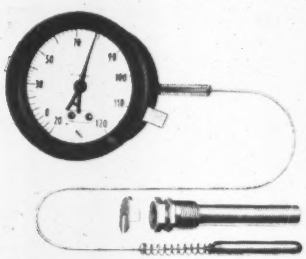
VAPOR-PRESS THERMOMETER

New remote reading, 2½"-size vapor-pressure-actuated Dial Thermometer (Type 6440 and 6470 Series) has spring-clamp bulb and well assembly, allowing conversion from



plain to well-type bulb in a few seconds. Adjustable pointer recalibration simple and quick. Ranges from —40/65°F to 260/450°F and 0/.100°C to 90/185°C—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

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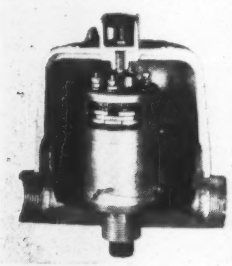
EXPLOSION-PROOF GOVERNOR

New GH-E Series covers over- and under-speed Governors together with 1, 2, & 3-element speed switches in



an explosion-proof enclosure meeting all of the specifications of Class 1, Group D.—*Synchro-Start Products, Inc.*, 8151 *N. Ridgeway Ave., Skokie, Ill.*

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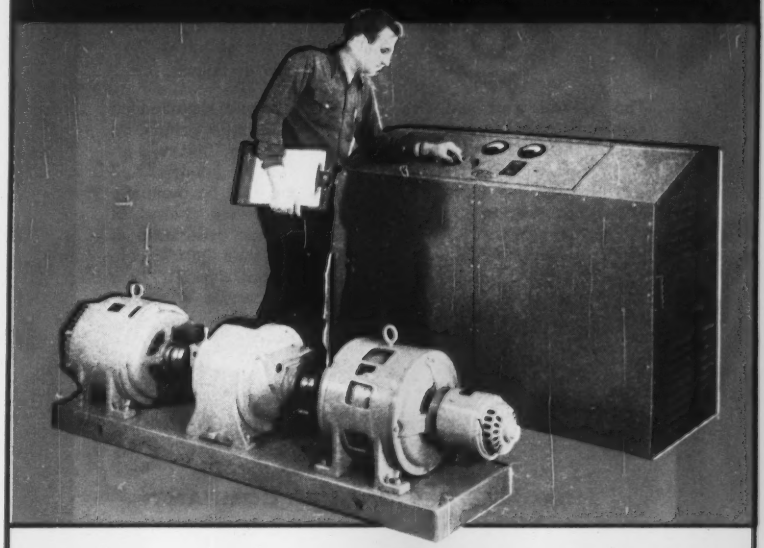

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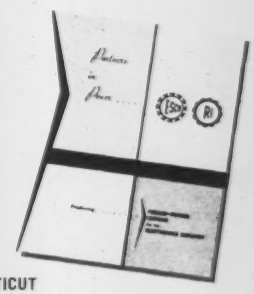
Everybody's doing it...in Computers, Automation, Telemetry, Ground Support. Incidentally, **ignore** old-fashioned prejudices about rotary equipment...this is "turn-it-on-and-forget-it" gear...we even build them **brushless,** if you object to routine once-a-year maintenance.

Skeptical? Write today for this complete, authoritative, 32-page illustrated technical manual describing ESCO-RI PRECISE POWER SYSTEMS.



ESCO ELECTRIC SPECIALTY CO.

Partners in Power

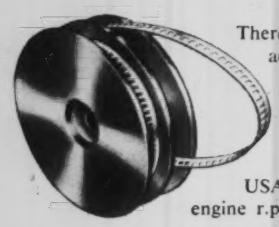
205 SOUTH STREET, STAMFORD, CONNECTICUT

Fireside 8-6203

RI REGULATORS, INC.

CIRCLE 81 ON READER-SERVICE CARD

SUCCESSFUL LAUNCH...

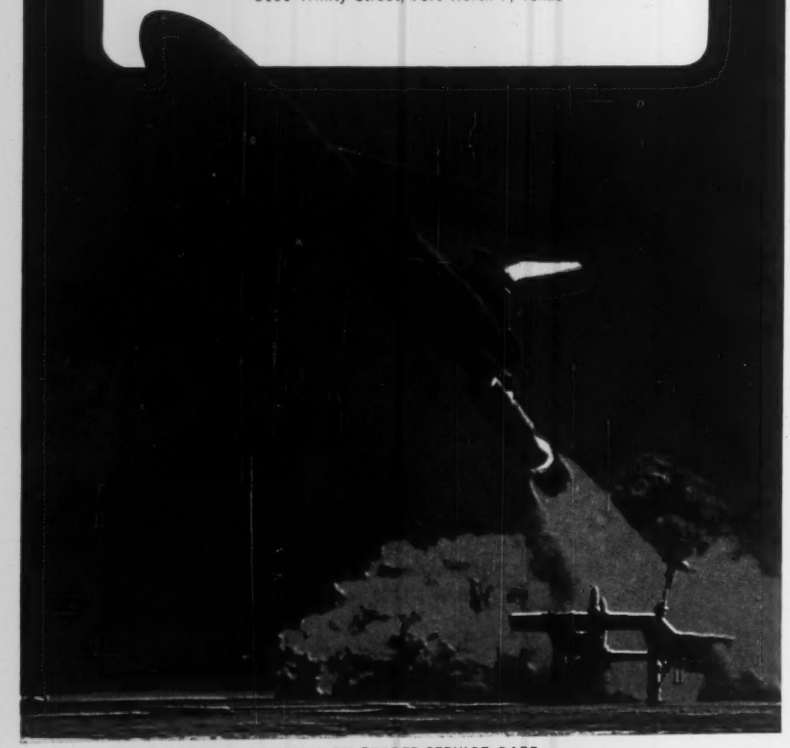


There's solid assurance in the high accuracy of Howell Instrument's Ta'Pot®, the "tape-slidewire" potentiometer used as the key measuring unit to check, *before* launch, The Martin Company's USAF TM-76 "Mace" engine r.p.m. and temperature systems—and which is the go/no-go control *during* launch.

The Ta'Pot is a straight wire (or helically wound!), embedded within the edge of a polyester tape. With calibration printed on the tape, this 12-feet long slidewire pot has up to 1200 readout scale points; or it may be geared to an in-line counter, and servo-driven in either case. *Or* the Ta'Pot may be manually operated for exact readout of functions...or for control of functions...or for computer inputs. Electronic calibration of Ta'Pot slidewires regularly achieves better than 0.05% conformity to either linear or non-linear functions. *The Ta'Pot is presently used in test cells, in jet engine analyzers, in jet aircraft cockpits and in a host of other critical applications.*

TA'POT®

HOWELL INSTRUMENT COMPANY
3101 Trinity Street, Fort Worth 7, Texas

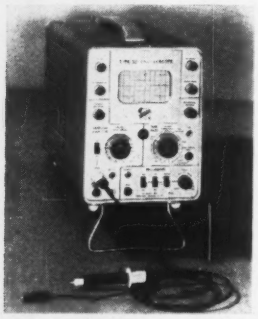


CIRCLE 82 ON READER-SERVICE CARD

NEW INSTRUMENTS

PORTABLE OSCILLOSCOPE

New Type 321 is a transistorized battery-operated portable Oscilloscope. Will operate 3 hours on ten high-current (Size D) flashlight cells;



up to 6 hours on rechargeable cells; also on 11 to 35 vdc, and on 110 to 125 v or 220 to 250 v, 50 to 800 cycles. Weighs only 12 pounds without batteries and measures only 5" x 8" x 16". Vertical passband is dc to 5 Mc, rise-time is 0.07 μsec, deflection factor is 10 mv/div.—*Tektronix, Inc., P. O. Box 831, Portland 7, Ore.*

CIRCLE 199 ON READER-SERVICE CARD

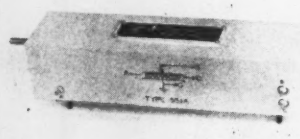
MEMORY SWITCH

New Transwitch, is a latching device which, when turned on, stays on after the turn-on signal has been removed, and similarly, when turned off, stays off after the turn-off signal has been removed. It eliminates the need for the two-transistor "flip-flop" design and thus lends itself to microminiaturization. Operation is in the 2-10 ma range at voltages up to 20.—*Transitron Electronic Corp., 168 Albion St., Wakefield, Mass.*

CIRCLE 200 ON READER-SERVICE CARD

VARIABLE DELAY LINE

New continuously variable delay line having 40 turns and 14400° rotation features transmission characteristics superior to delay lines of distributed or lumped type, fast rise



time, excellent stability, hairline accuracy, ratio of total time delay to resolution time of over 10,000, and complete freedom of time jitter. Total delay can be extended to 10 μsec.—*Ad-Yu Electronics Lab., Inc., 249-259 Terhune Ave., Passaic, N. J.*

CIRCLE 201 ON READER-SERVICE CARD

an electronic control success story every process engineer will want to read...

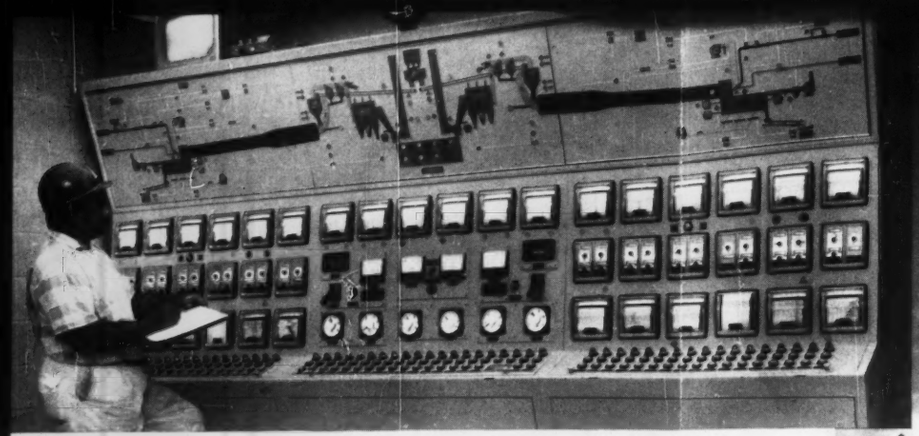
Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

- No oil filters.
- No dust filters.
- No internal lubrication to contaminate air handled.
- No internal wearing parts.
- No valves, pistons, or vanes.
- Non-pulsating pressure.
- Original performance constant over a long pump life.
- Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.



Riverside's computer-controlled plant now on-stream with Foxboro Electronic Consotrols

pressures — temperatures — flows all electronically controlled

Giant, gas-fired cement kilns, 310′ long, 10′ and 12′ in diameter — they're under complete Foxboro electronic control at Riverside Cement Company, Oro Grande, Calif. All process variables, including pressures, temperatures, motion, differential pressures, motor speeds, gas-analysis, and gas-air ratios are included in this fully co-ordinated instrument system.

Riverside's Electronic Consotrol* Instrumentation includes transmitters, controllers, recorders, converters, integrators, alarms — all solid-state — all linked by a common 10-50 ma, d-c signal. Transmission is over simple, unshielded lines. And this ultra-modern control system is fully compatible with process control computers.

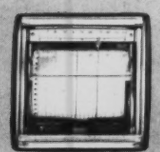
Foxboro Electronic Consotrol Instrumentation is ideal for chemical plants, refineries, steel mills, nuclear reactors — wherever precise, rapid, long-distance control is required. Ask your local Foxboro Field Engineer about Electronic Consotrols — or write for Bulletin 21-10. The Foxboro Company, 4610 Neponset Avenue, Foxboro, Mass.

*Reg. U. S. Pat. Off.

Typical application of Foxboro Electronic Consotrol Instrumentation . . . Riverside Cement Company's modern plant at Oro Grande, Calif. 310′ kilns have all process variables under Foxboro electronic control. Other major Foxboro electronic installations include petrochemical plants in the U. S. and Canada, nuclear reactors, as well as unattended booster stations on a 680-mile crude oil pipe line.

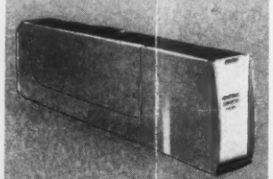
AN ELECTRONIC CONSOTROL INSTRUMENT FOR EVERY CONTROL LOOP FUNCTION

Recorders
No amplifiers, slidewires, or servo motors. Operate completely independent of controller. 1 and 2-pen models, with 4" vertical strip chart.

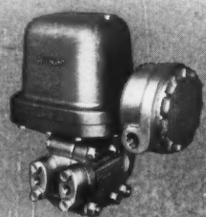


Indicating Transmitters
Use any standard Foxboro measuring element — continue to measure and indicate even in event of power failure.

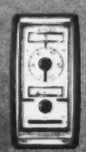
Electrical Converters
Convert EMF and Resistance measurements to a 10-50 ma, d-c signal. Rack or panel mounted. No batteries, no slidewires, no servos.



2-wire Transmitters
For measurements such as pressure, absolute pressure, differential pressure, and level. Require no local power supply.



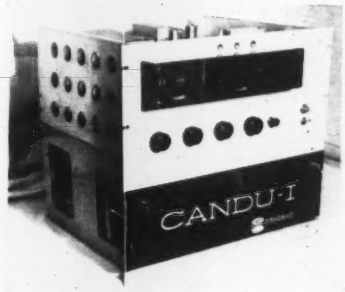
Indicating Controllers
May be mounted individually or in same housing with recorder. Each operates and pulls out from panel — completely independent of the other.



FOXBORO

20-CHANNEL DATA SYSTEM

New Candu-I data Logging System scans up to 20 analog channels at a rate of four per second with a visual display on Nixie tubes or actuating mechanical printers, tape punches or

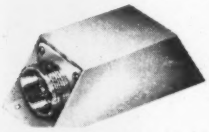


electric typewriter. Especially useful for strain gage and thermocouple use. Accuracy is better than 0.25% of full scale including linearity, drift, and gain stability. Input impedance is greater than 500,000 ohms. Data Sheet 2007 gives details.—*Franklin Electronics, Inc., Bridgeport, Penna.*

CIRCLE 202 ON READER-SERVICE CARD

SERVO VALVE AMPLIFIER

New Servo Amplifier for proportional control of hydraulic transfer valves in missile and aircraft guidance systems uses magnetic ampli-

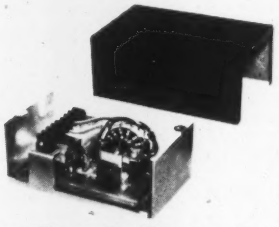


fiers, and silicon semiconductors and resistors. Output is 8 ma dc push-pull into two 1400 ohm loads; control signal is 0.5 to 2.0 vdc into 3000 ohm load.—*Vickers Inc., Electric Products Div.*, 1815 *Locust St., St. Louis* 3, *Mo.*

CIRCLE 203 ON READER-SERVICE CARD

SEQUENCE CONTROLLER

New Sequence Controller Model SC 500, is capable of switching from two to 12 circuits in a predetermined se-



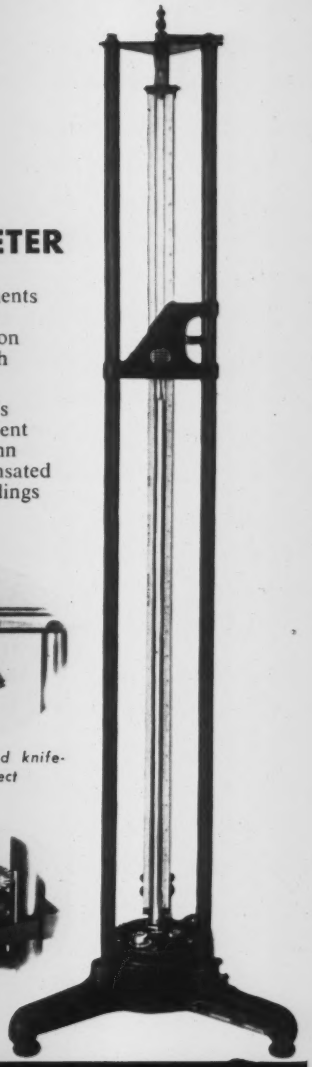
quence. The unit will repeat the same predetermined sequence as long as actuation pulses are fed into it. These pulses can come from a limit switch, foot switch, photoelectric control relay or any other conventional equipment.—*Warco Industries, Inc.*, 6625 *Delmar Blvd., St. Louis* 3, *Mo.*

CIRCLE 204 ON READER-SERVICE CARD

← **CIRCLE 83 ON READER-SERVICE CARD**

measure absolute
and differential pressure
accurately, easily
with

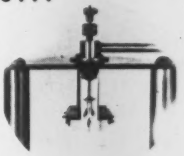
W & T PRECISION MERCURIAL MANOMETER



For all types of precise pressure measurements in production, research, or analysis, the Wallace & Tiernan Type FA-135 Precision Mercurial Manometer gives readings with an accuracy of 1:3000.

And the W&T Mercurial Manometer is convenient to use. It is the one instrument which permits reevacuation of its column at any time. Scale is temperature compensated and no zero adjustment is required. Readings are taken at a glance.

unique, advanced features . . .



Mercury-sealed valve provides easy means for evacuating and sealing the tube.

Magnifying eyepiece and knife-edge indicator give direct readings.

Simple dial setting compensates for ambient temperature changes. No mathematical corrections required.

For full information on all models of W&T Precision Mercurial Manometer, write Dept. A-125.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
IN CANADA: WALLACE & TIERNAN LTD., WARDEN AVE., TORONTO 13, ONT.

is your feeding problem peculiar to your operation?

Wallace and Tiernan's volumetric feeders are so flexible that each job is practically custom built. W&T's experience is broad enough to meet any challenge.

Try us - for information write Dept. MV-1.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

MANOMETERS—CIRCLE 84 ON READER-SERVICE CARD
FEEDING—CIRCLE 85 ON READER-SERVICE CARD

Announcing

conax®

con-O-clad®

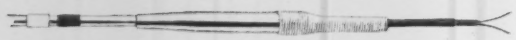
mineral insulated thermocouples

All steps of manufacturing and testing Con-O-Clad are in keeping with the Conax policy to produce only *highest quality products.*

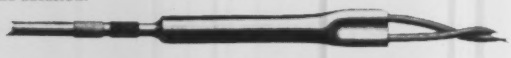
Conax is the *only* manufacturer of mineral insulated thermocouples making a complete line of pressure fittings and terminations for entire assemblies ready for installation.

Conax Con-O-Clad is available with single, double and multiple thermocouple wire.

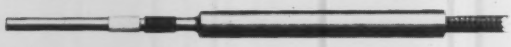
TYPICAL LEAD WIRE TERMINATIONS



Above *exclusive* Conax design provides a practically unbreakable connection between lead wire and thermocouple. Spring reduces vibration and abrasion.



Another *exclusive* Conax design eliminates strain on lead wire and thermocouple connection. Formed crimp increases structural strength.



Stainless steel braid protects lead wires and provides maximum flexibility. Braid embedded in potting compound prevents liquid and gas penetration.

Write for FREE functionally-colored DATA BOOK showing complete line of over 20,000 Con-O-Clad assemblies.

conax corporation

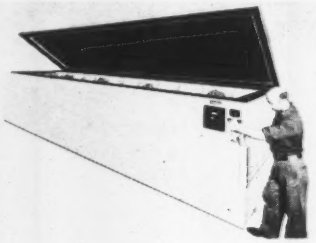
2316 Walden Ave., Buffalo 25, N. Y., Telephone, REgent 0600

CIRCLE 86 ON READER-SERVICE CARD

NEW INSTRUMENTS

ENVIRONMENTAL CHAMBER

New Model WT-280-125 Environmental Chamber has an interior capacity of 280 cu ft and the ability to cool a 20,000-pound piece of steel 215° with perfect control of environmental conditions. An exclusive patented Cas-

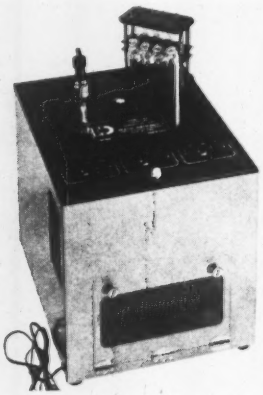


cade cooling system is vapor charged with 110 pounds of refrigerant vapor, eliminates high-pressure leaks in case of power failure and equalizes pressure between cascade and evaporator. As the refrigerant tends to mix with motor heat, gases and oils, a unique heat exchanger system is installed between the compressor discharge and the oil separator. This safeguard removes friction and motor input heat from the hot gas.—*Webber Mfg. Corp., Indianapolis, Inc.*

CIRCLE 205 ON READER-SERVICE CARD

STANDARD-CELL BATH

New bath maintains a bank of 12 standard cells at a constant temperature of ±0.01°C. Cells are immersed in a tank of neutral oil, and the oil



temperature is maintained throughout its volume at 35°C by a circulating system.—*Daystrom-Weston Sales Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

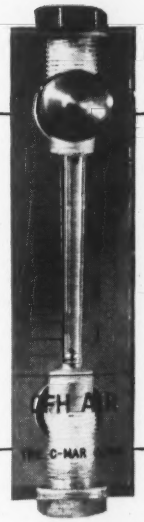
CIRCLE 206 ON READER-SERVICE CARD

POWER, FACILITIES, AND COMMUNICATION CHANNEL

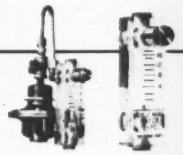
New Channel, a prefabricated, preengineered unit made up in 5-ft modules and less than 3" in width, holds all plant power and facility lines,

Low Cost PURGE METERS

*Simple *Safe *Sure



New Series C M acrylic plastic PURGE METERS have been developed for all purging applications requiring a positive flow indication and maximum reproducibility of small flow conditions. Drilled, reamed and polished, these precision engineered units provide the ideal method of inexpensively measuring small gas or liquid flows where high accuracy is not paramount. Etched scales permit direct, easy readings and advanced flow control valve offers improved convenient control. Solid, one piece construction insures trouble-free operation. From $5.00.



Send for Bulletin 0100

C MAR corporation

35 Euclid Avenue, Manasquan, N. J.

EXPORT DIVISION: Empire State Bldg., N. Y. 1, N. Y.

CIRCLE 87 ON READER-SERVICE CARD

- Hot Water Systems
- Floors, Walls, Ceilings
- Refrigerated Coils
- Insulation
- All Other Low Temps.

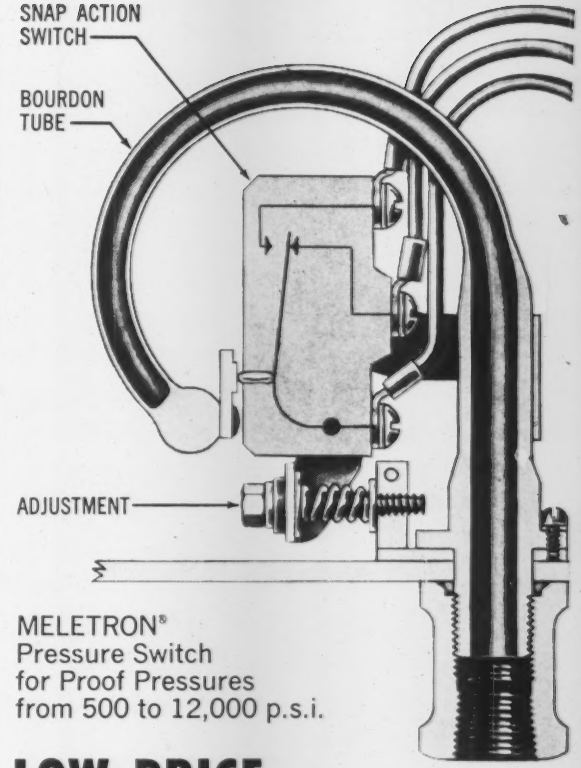
You can accurately read any low surface temperature with the Alnor Type 2300 Surface Pyrometer—in 3 to 5 seconds.

Take this rugged, portable instrument to any job in the field and see how performance to laboratory standards can save invaluable time in balancing out a system...save the money lost on call-backs. Large 6" mirrored scale is direct reading, no conversion...no errors in readings...1° per division. Precision jeweled movement is protected against abuses of portable service by sturdy walnut case. Comes complete with matched thermocouple and lead ready to use on your next trip out. Send for Bulletin 4257. Tear out this ad and mail on your letterhead to: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle Street, Chicago 10, Illinois.

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Alnor

CIRCLE 88 ON READER-SERVICE CARD



MELETRON® Pressure Switch for Proof Pressures from 500 to 12,000 p.s.i.

LOW PRICE

Instrument Quality

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS

which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it critical to vibration.

To get complete operating characteristics and specifications ask for Catalog 9-PS.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

CIRCLE 89 ON READER-SERVICE CARD

- a wide range of standard sizes
- colored tubing and special sizes
- a wide range of wall thicknesses
- prompt deliveries of

SPAGHETTI TUBING MADE FROM

TEFLON*

by Pennsylvania Fluorocarbon

To obtain outstanding results from sheathing for wires, slip-on insulation and bushings, use the unique electrical properties of spaghetti tubing made from Teflon plus the outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon.

The unique electrical properties of spaghetti tubing made from Teflon include: good dielectric strength (1000-2000 volts/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature (-25°C. to +250°C.), or frequency (60 cycles to 100 mc.); unaffected by moisture. In addition, PF Teflon is not harmed by the hot soldering iron so assembly work is speeded up considerably.

The outstanding engineering and manufacturing techniques developed by Pennsylvania Fluorocarbon include: the tailoring of Teflon with colors for identification or with modifications for improved texture and mechanical properties; stress relieving spaghetti tubing for minimum shrinkage; cleaning and 100% inspection; the manufacture of a wide range of wall thicknesses and special sizes.

Write, wire or call and let us quote on your requirements. We can provide overnight delivery of standard sizes and many special sizes at competitive prices.

PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa.

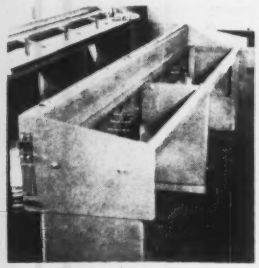
EVergreen 6-0603 TWX: PH 252

*DuPont registered trademark

CIRCLE 90 ON READER-SERVICE CARD

NEW INSTRUMENTS

such as electrical, hydraulic, air, steam, gases, coolants, vacuum lines, refrigerants, air, water, drain lines,

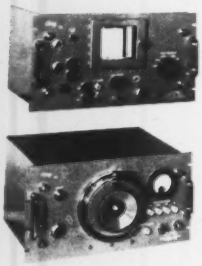


etc.—*Alden Systems Co., Alden Research Center, Washington St., Westboro, Mass.*

CIRCLE 207 ON READER-SERVICE CARD

RADIOACTIVITY MONITOR

New Model 34 Tritium Monitor detects 10^{-12} curies of tritium per ml in air (0.04 mrep dose per hour) and sounds an alarm when radio-activity

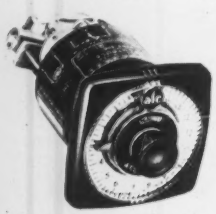


exceeds safe limits. Instrument consists of a sampling unit and a control unit connected by a cable which can be up to 50 ft long and permits locating the sampling unit in a hazardous location while the control unit containing a recorder is placed at a safe, remote location.—*Applied Physics Corp., 2724 South Peck Rd., Monrovia, Calif.*

CIRCLE 208 ON READER-SERVICE CARD

D-C TIMER

New Atcotrol Series 305 Miniature Reset Timer controls d-c loads within variable timed intervals or sequences with a repeat accuracy of ¼%. Seven basic circuit arrangements provide an

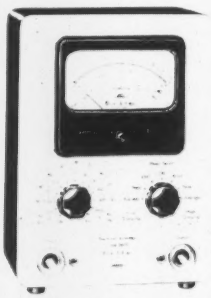


infinite number of combinations for control of automatic functions. Two or more Series 305 timers can be combined for repeat cycle operation, with each timer adjustable to desired timing interval, either for reset or non-reset on power failure.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 209 ON READER-SERVICE CARD

ELECTRONIC VOLTMETER

New Electronic Voltmeter, Model 2409, made by Bruel & Kjaer in Denmark measures either the true rms,

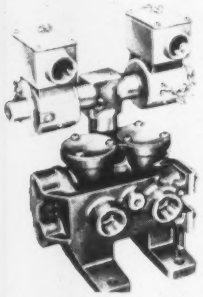


peak, or average values of voltages over the frequency range from 2 to 200,000 cps. An accuracy of 0.5 db is obtained for true-rms indication of signals with crest factors up to 5 and over a 20 dynamic range.—*B & K Instruments, Inc., 3044 West 106th St., Cleveland 11, Ohio.*

CIRCLE 210 ON READER-SERVICE CARD

MOMENTARY-CONTACT VALVES

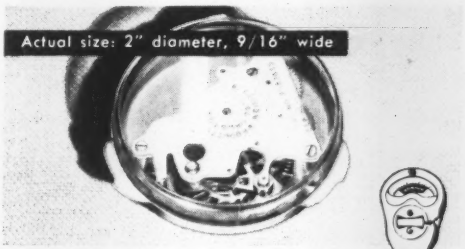
New single Solenoid 2-position 4-way Valve (the pressure port is open to cylinder #2 port, cylinder #1 port is open to exhaust in the normal position) applies current only for the instant it takes the valve to change position. It remains in that position with the power off. When an electric im-



pulse once more energizes the solenoid, the solenoid plunger "unlatches" the contact device and allows the pilot valve and main valve members to revert to the original normal position. In Dual Solenoid Units (see illustration) solenoid #1 is actuated and the pilot valve is latched as described above. Additional electric impulses to solenoid #1 will not unlatch the pilot valve. Only by actuating solenoid #2 will the valve revert to its normal position.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

CIRCLE 211 ON READER-SERVICE CARD

PRECISION ESCAPEMENTS



...key to a multi-million dollar business

Over three quarters of a million PRECISION escapements are used daily in parking meters across the country. Others are at work in time control mechanisms of all kinds.

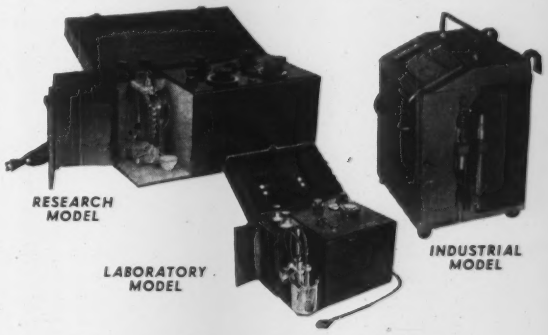
PRECISION-built units are compact . . . especially adaptable where space is limited and *consistent* accuracy and long life essential. Write for our literature and see how precision escapements can contribute to profits in your business.

PRECISION PRODUCTS, INC.

DESIGNERS AND MANUFACTURERS OF MECHANICAL TIMERS • INSTRUMENTS • PRECISION PARTS AND ASSEMBLIES

Dept. ICS-458 • 530 SOUTH QUAKER • TULSA 20, OKLAHOMA

CIRCLE 91 ON READER-SERVICE CARD



Cambridge pH Meters

The three portable models illustrated above incorporate new and important advantages. A.C. line operation eliminates battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is direct-reading, continuous-indicating; ruggedly built for plant use.

Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Cambridge pH equipment also includes single- and multi-point indicators and recorders. Send for Bulletin 910-M.

CAMBRIDGE INSTRUMENT COMPANY, INC.

3554 GRAND CENTRAL TERMINAL, NEW YORK 17, N. Y.

Pioneer Manufacturers of

PRECISION INSTRUMENTS

CIRCLE 92 ON READER-SERVICE CARD

ARE YOU PROPERLY GEARED FOR

MINIATURIZATION?

USE THE PERFECT COMBINATION For MICRO-DRILLING

SPHINX

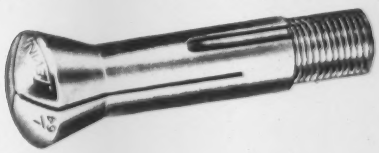
HIGH SPEED STEEL MICRO-DRILLS

Drills from .0016" to .0591" are stocked in increments of .0004"(.01 mm). From.0610" to .1181" in increments of .0020" (.05 mm). Left hand micro-drills for use on Swiss type automatic screw machines. Short flute center drills. Send for Bulletin "Q" listing complete line of drills or Catalog M listing collets as well as full line of instrument lathes and accessories.

Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, California.

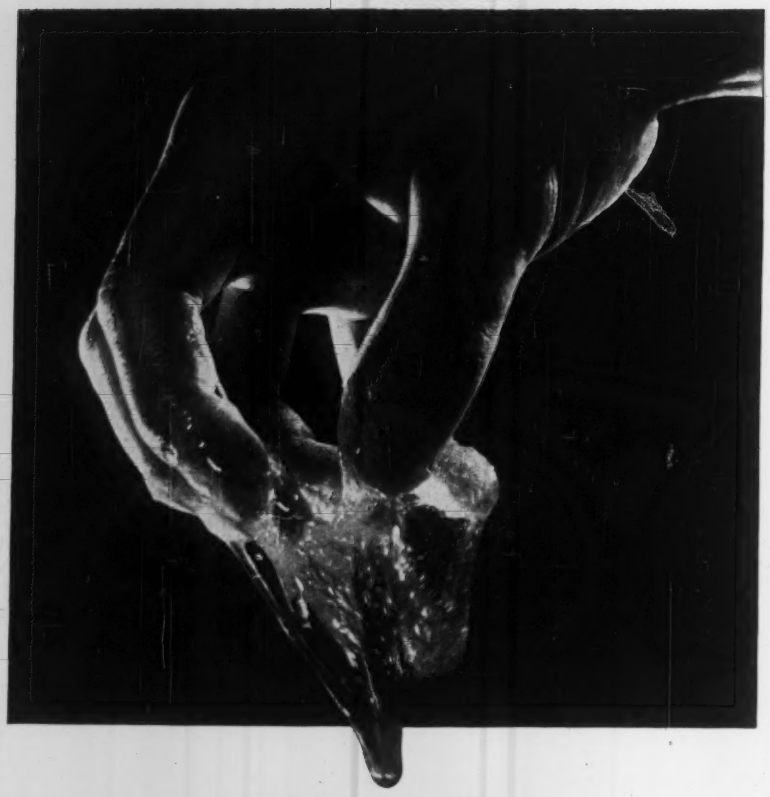
LEVIN ®

SUPER PRECISION **COLLETS**



Super precision collets for jewelers type lathes. Ideal for holding micro-drills or other parts where concentricity is important. Available from stock in complete range of sizes from .004" (.1 mm) to 5/16" (8.0 mm).

CIRCLE 93 ON READER-SERVICE CARD



VISCOSITY

A product dimension as important as Ph, color or stability. Accurate viscosity control turns chance to science — waste to wealth.

BROOKFIELD

The name you can depend on when you see it on any viscosity measurement or control instrument.

YOU AND THE CHEM SHOW

You are a scientist, the coming Chem Show will be our meeting ground. Booth #855-57 will conveniently show in live operation the Brookfield Viscometran now in use successfully for polymerization end point determination and continuous "in process" viscosity recording. See and try, the famous Brookfield viscometers in a broad range of models, look over the many Brookfield accessories which give the Brookfield viscometer its famous flexibility. At the Chem show, anytime, make Brookfield your first source for viscosity information.

The world's standard for viscosity measurement and control

Brookfield know how is yours for the asking without obligation

Brookfield

ENGINEERING LABORATORIES INCORPORATED
STOUGHTON 116, MASSACHUSETTS
CIRCLE 94 ON READER-SERVICE CARD

NEW INSTRUMENTS

A-C/D-C CONVERTER

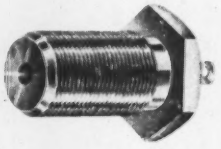
New Linear A-C to D-C Converter, Model 710, converts an a-c voltage to a d-c voltage which can be measured with an accurate d-c device. With such a combination accuracy up to

0.25% is obtained for a wide range of voltages. A-c input voltage range is from 1 mv to 1000 v, which is divided into six decade ranges. For every decade range the d-c output varies from 0.1 v to 1 v. Output d-c is proportional to the average value of the input waveform for sinewaves and distorted waveforms up to 30% total distortion.—*Ballatine Laboratories, Inc., Boonton, N. J.*

CIRCLE 212 ON READER-SERVICE CARD

SPST PRESSURE SWITCH

New line of electronic Pressure Switches, Model 419, responding to pressure changes in hydraulic fluids, fuels, gases, or liquids meets MIL-E-



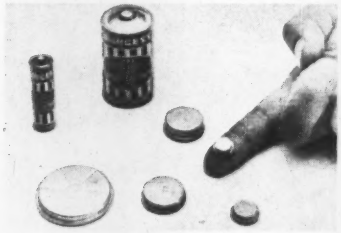
005272B, Procedure 1 specifications for vibration level, shock, acceleration and humidity. Specifications—Pressure range: 1 to 500 psig; overpressure without shift: 3000 spig; output: SPST switch, normally closed; operating temperature range: −65°F to +165°F.—Bulletin 419/H/9 gives details.—*Bourns, Inc., P. O. Box* 2112, *Riverside, Calif.*

CIRCLE 213 ON READER-SERVICE CARD

RECHARGEABLE Ni-Cd BATTERIES

New rechargeable, sealed nickel-cadium Cells and Batteries are marketed in eight sizes, as well as a range of multiple cell batteries in numerous voltages. The individual cells, rated at 1.25 v include six button-type units ranging from a finger-tip sized cell (0.4" dia) to one slightly larger than a silver dollar. Development of a

nique conductive silver wax inter-cell connection permits cells to be connected in series merely by being stacked in a column with a permanent inter-cell connection. Recharging re-

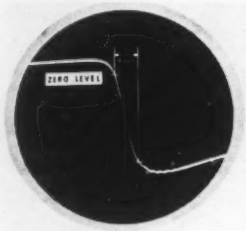


stores the batteries to peak operating efficiency hundreds of times with equally good response to either a slow or fast charge.—*Burgess Battery Co., Dept. CD-500, Div. of Servel, Inc., Freeport, Ill.*

CIRCLE 214 ON READER-SERVICE CARD

PULSE TUBE

New 9-pin miniature Secondary Emission Pulse Tube, CBS 7548, features rise time of less than 5 μsec. with a one-amp pulse. Currents as high as one amp and rep rates up to

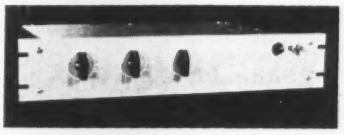


300 kc are possible as a result of the tube's high dissipation capabilities. Combined are high transconductance (25,000 micromhos at 18 ma) and low capacitances for a gain-bandwidth product of 350. Bulletin E-352 gives details.—*CBS Electronics, 100 Endicott St., Danvers, Mass.*

CIRCLE 215 ON READER-SERVICE CARD

DIGITAL CALENDAR

New Model 2800 Digital Calendar produces a parallel, decimal representation of the date in months and days, suitable for data loggers, com-



puters, etc. Logic circuits automatically correct its output for 30- and 31-day months and leap year. Wiring permits actuating either parallel or serial devices.—*Chrono-log Corp., Dept. I, Box 4587, Phila. 31, Pa.*

CIRCLE 216 ON READER-SERVICE CARD

don't guess Liquid Levels...

Specify a Liquidometer Gauge

Easy to read as a clock. A Liquidometer Gauge indicates the exact level at all times ... shows it at a glance. And gauge operation is completely automatic – as far as 250 feet from the tank – without need for auxiliary power of any kind.

A Liquidometer Tank Gauge measures virtually any liquid. It's simple to install – requires no maintenance. Many have provided over 30 years of efficient, dependable service. All are approved by Underwriters' Laboratories and Factory Mutual.

Whether your gauging needs require an automatic Liquidometer Gauge, a hydrostatic Levelometer or a tank-site-indicating Direct Reader, you'll get the best by specifying Liquidometer. For complete details write Dept. E.

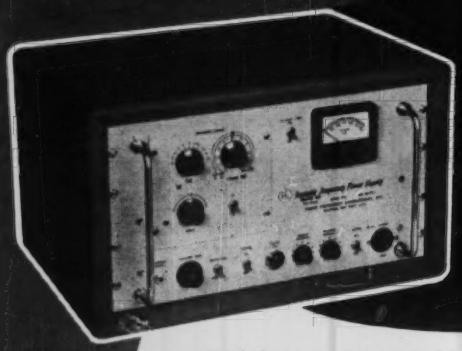
Since 1920 LIQUIDOMETER INSTRUMENTS ...of proven quality

THE LIQUIDOMETER CORP.

LONG ISLAND CITY 1, NEW YORK

CIRCLE 95 ON READER-SERVICE CARD

Laboratory Power Supply



MODEL 150
features
VARIABLE FREQUENCY OUTPUT
380-2400 cps.

With front panel control of feedback for improved load matching, the Model 150 provides 150 volt-amperes for 1.0 to 0.7 leading or lagging power factors. Consuming about 450 watts from a nominal 115-volt 50/60 cycle line source, its output voltage is adjustable from 105 to 125 volts (0-130 volts as a power amplifier). Output voltage regulation is ±2% for load or line as an oscillator (as a power amplifier, regulation is dependent on feedback control setting and power factor of the load).

Total output distortion at full load is about 1.5% at 400 cps. At 50 watts, distortion is less than 1% from 100-500 cps.

Output frequency variation due to rated line and resistive load changes is less than 0.1% ±2 cycles. Frequency variation due to a change of 100 VA of reactive load is about 0.5%.

Cabinet is 21-1/2" wide x 13" high x 15" deep and is equipped with ventilating fan. Front panel is 19" wide x 10-1/2" high and can be mounted on standard relay rack. Net price $575.

For Owners of the RFL Model 829 AC-DC Instrument Calibration Standard

By combining the Model 150 with the Model 829 and the Model 10 Test Equipment Cart, a complete meter calibration facility can be achieved in a small space.

The cart is made of heavy gauge sheet steel and is equipped with free rolling, swivel casters. Usable inside space is 33" wide x 16-1/2" deep x 26" high. One side accommodates standard 19" wide panels to meet RETMA rack standards; the other side has 24" wide opening for equipment mounted in cabinets, such as the Model 150. Interior shelf is adjustable in any position from top to bottom. Accessory, drop-leaf work counter, attachable to either side of the cart, is also available.

Performance is rigidly guaranteed. Price is net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

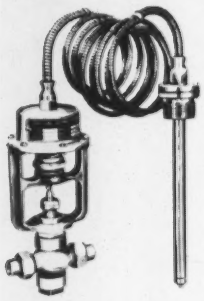
RFL *Radio Frequency* LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 96 ON READER-SERVICE CARD

NEW INSTRUMENTS

TEMPERATURE REGULATORS

New Type TC and TCX Series Temperature Regulators for use on water heaters, fuel oil preheaters, fuel oil coolers, and storage tanks are

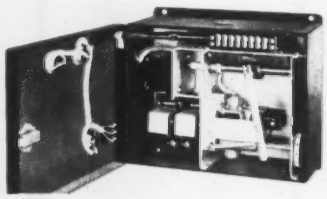


vapor-pressure operated, and are either direct acting or reverse acting. Both types are available with bronze bodies in sizes from ¼" to 2", with union connections, the TC series also in iron or bronze bodies from 2½" to 5", with 125-lb ASA flanged ends. Bulletin No. 7-1 gives details.—*Cash-Acme, P. O. Box* 191, *Decatur, Ill.*

CIRCLE 217 ON READER-SERVICE CARD

MASTER CONTROLLER

New Master Controller, for combustion control systems is a fully automatic, heavy-duty sensing and controlling instrument, responsive to minute changes in pressure or tem-



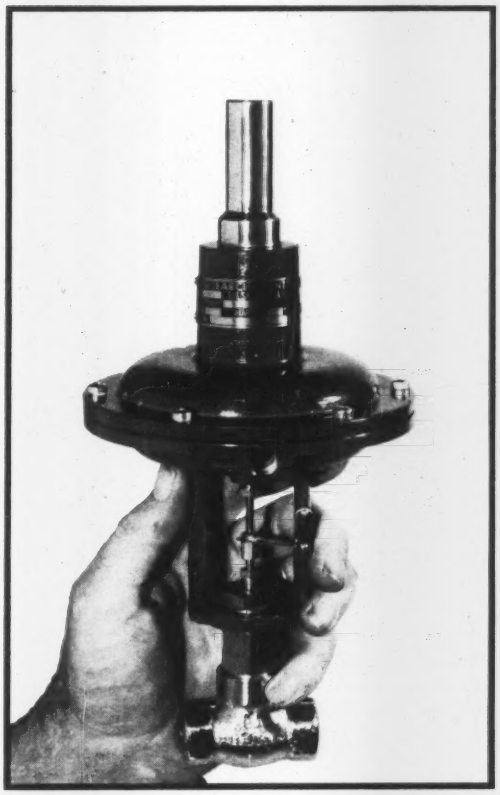
perature, and transmitting line voltage signals to other system components for control of firing rate, damper positioning, valving, or other regulation. Sensitivity is adjustable to an accuracy of 1% of the control set point. Pressure ranges are: 0 to 30, 20 to 100, and 75 to 300 psig. 12-page Catalog CMC-687 gives details. —*Cleveland Controls, Inc.*, 1111 *Brookpark Rd., Cleveland* 9, *Ohio.*

CIRCLE 218 ON READER-SERVICE CARD

ANALOG COMPUTER

New Dystac (Dynamic Memory & Storage Analog Computer) system synthesizes the analog computer's speed, lower cost, ease of programming, etc. with the digital computer's unique capacity for data storage and time-sharing of computing elements. Basic unit has 48 amplifiers, field-expandable to 80 operational amplifiers;

MINIATURE DIAPHRAGM MOTOR VALVES



MATERIALS OF CONSTRUCTION

BODY: Steel, 304 S/S, 316 S/S, Bronze, Monel, Hastelloy B or C OR ANY MACHINEABLE MATERIAL
PACKING: Teflon, Braided or Molded
TRIM: 300 SER. Stainless Steel, Monel, Hastelloy B or C
TOPWORKS: Cast aluminum with neoprene diaphragm

INNER VALVES

Quick opening — any size, Linear — all sizes
Equal percentage — Cv 0.05 and larger

CONNECTIONS

Screwed NPT 1/4" and 1/2", FLANGED, WELDED, ETC.

Cv VALUES

SIZE	Cv's AVAILABLE
1/2"	3.0 DOWN TO 0.05
1/4"	0.32 DOWN TO 0.0001

RESEARCH CONTROLS

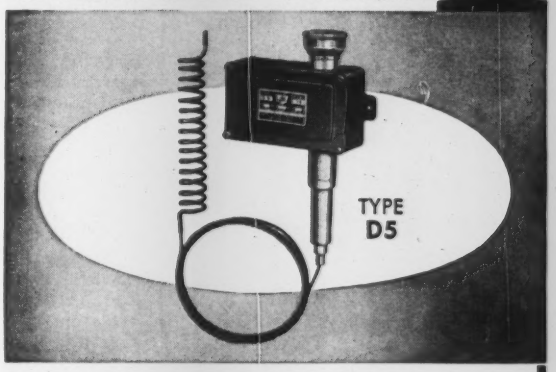
INCORPORATED

P. O. BOX 5035 TULSA, OKLAHOMA

See our Exhibit, Booth No. 1186, International Exposition Chemical Industries, New York Coliseum; November 30 through December 4.

CIRCLE 97 ON READER-SERVICE CARD

MICROMETER-ADJUSTED REMOTE BULB TEMPERATURE CONTROL D5



UNITED ELECTRIC's Type D5 Remote Bulb Temperature Control is a precision unit containing a micrometer adjustment for obtaining wide ranges and accurate temperature settings. This control has found extensive use in applications such as laboratory and industrial ovens, water baths, hot plates, etc.

Temperature Ranges	−150°F. to +200°F., 70°F. to 370°F., 100°F. to 650°F.
Switch Ratings	15 amps at 115 or 230 volts AC. Also 20 amps or DC switches on specification.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Three-turn, calibrated knob rotated against graduated barrel. Readings and divisions equally spaced over entire range. Adjustment knob includes calibration screw.
Electrical Connections	Made to internally located terminal block via clearance hole in the enclosure.
Capillary Tube Length	Standard length six feet. Other lengths available.
Enclosure	Die-cast aluminum case with black wrinkle finish. Other finishes available.
Mounting	Control head surface mounted in any position by means of dog ears. May also be flush mounted.

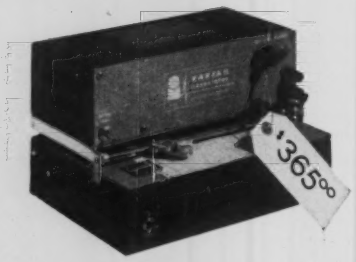
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. Additional data on the Type D5 and other standard remote bulb temperature controls are contained in* Section 200 *of our* new *catalog. Write for your copy now.*

United Electric Controls COMPANY

83 SCHOOL STREET, WATERTOWN, MASS.

CIRCLE 98 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS
Used by the thousands
because . . .



2. PERFORMANCE AT

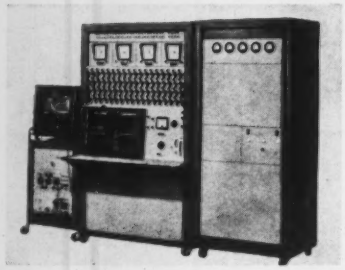
LOW COST

As little as $365 for a sensitive, rugged potentiometer recorder. Varian Recorders are accurate to 1% and rugged enough to do round-the-clock production-line checkout or round-the-calendar monitoring of long-term laboratory experiments.

Full-scale balancing time 1 or 2½ seconds; weight 15 pounds; ranges from 0-9 millivolts to 0-100 volts; wide choice of speeds, accessories and charts. Full specifications and description of models available by writing the Instrument Division.

VARIAN associates
PALO ALTO 27, CALIFORNIA

CIRCLE 99 ON READER-SERVICE CARD

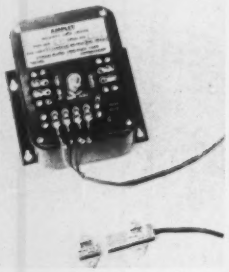


larger systems are equipped with 222 operational amplifiers, 90 electronic multipliers, and 30 ten-segment diode function generators.—*Computer Systems, Inc., 611 Broadway, New York 12, N. Y.*

CIRCLE 219 ON READER-SERVICE CARD

MAGNETIC LIMIT SWITCH

New Amplet Magnetic Limit Switch, consists of three parts (none moving): a probe, normally mounted on a stationary part of the machine; a magnetic trigger, mounted on a moving part of the machine or on the

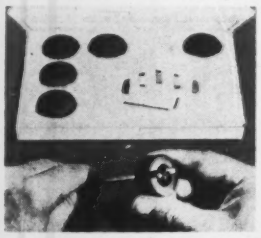


part being machined; and a power amplifier. By adjusting the latter's sensitivity the distance between probe and trigger at which action takes place is variable from 0.020" to 0.200". Power amplifier units are available either normally-off or normally-on. Output signal is 50 μa in the "off" condition and five watts of 24-vdc when "on".—*Consolidated Controls Corp., Bethel, Conn.*

CIRCLE 220 ON READER-SERVICE CARD

WIRE STRIPPER

New Con-O-Pak K-500 Kit for precision stripping of metal-sheathed ceramic-insulated thermocouple wires



can handle sheath diameters from 0.025" to 0.250". Kit consists of 6 strippers, 5 extra bits, and each handle a specific wire size.—*Continental Sensing, Inc., 1950 North Ruby St., Melrose Park, Ill.*

CIRCLE 221 ON READER-SERVICE CARD

MULTI-MINIATURE FEATURES
with
PACKLESS "DEMI G" VALVES

"DEMI G" SERIES

Packless "DEMI G" Valves are miniature in size, weight and price. They employ a patented form and give bubble-tight shut-off. They are available in many bar-stock materials with a wide variety of tee-handle and toggle actuators and have innumerable applications in the chemical, oil, instrumentation, aircraft and atomic energy fields . . . to name but a few.

Basic "DEMI G" Valves employ metal-to-metal seating, however TEFLON seats for vacuum service, neoprene diaphragms for toggle actuation and all TEFLON interior models . . . as well as those with bolted bonnets are standardly available. Where space and exacting control are considerations, the "DEMI G" Series of packless valves will do the job better.

PRESSURE RATING	
Metal Body & Diaphragm	750 psi at 450°F
Neoprene Diaphragm	100 psi at 180°F
TEFLON Body & Diaphragm	100 psi at 450°F
MAXIMUM Cv	0.4
CONNECTIONS	1/16" to ½" N.P.T.

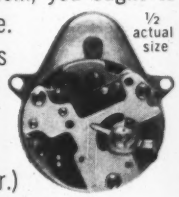
Send for the "DEMI" Catalog D-1 and other technical data on Dahl pneumatic and hydraulic valves.

GEORGE W. DAHL COMPANY, INC.
86 TUPELO STREET, BRISTOL, RHODE ISLAND

CIRCLE 100 ON READER-SERVICE CARD

WHO NEEDS FEED-BACK ?

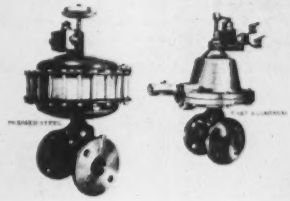
The patented chronometric governor of this standard DC Timing Motor is a tyrant: without any other circuitry, it holds the motor output speed within ±0.1% while driving charts, cams, contacts, actuators or other devices. It holds the rate even if output shaft load, line voltage, or ambient temperatures change. And that's just the standard model of this little gem: custom variations can do even better, under special conditions. **The A. W. Haydon Co. knows all about timers and timing.** If you have a specific timing problem, you ought to have our literature. Bulletin MO 802 is yours for the asking (5800 Series chronometrically governed DC Motor.)



THE AWH HAYDON COMPANY
228 North Elm Street, Waterbury 20, Connecticut
CIRCLE 101 ON READER-SERVICE CARD

SPRINGLESS VALVE ACTUATOR

New air-loaded springless Actuator for miniature valves employing a large-volume air chamber, sealed by a

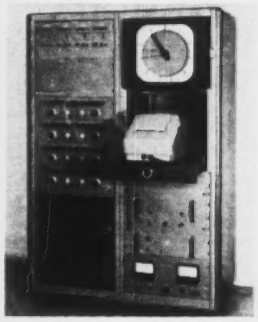


check valve, is furnished in normally-closed or normally-open models equipped with travel indicators. Illustrated are Saunders-patent valves.—*George W. Dahl Co., Inc., Bristol, R. I.*

CIRCLE 222 ON READER-SERVICE CARD

STRAIN GAGE RECORDER

New Strain Gage Recording System for testing structures, valves, etc. provides for selection of up to 40 strain gages and is expansible in modules of 10 points up to 100 points. System comprises a potentiometer



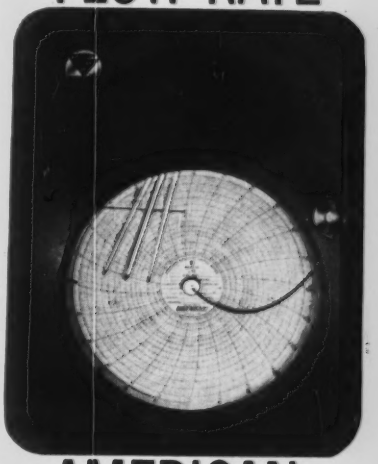
which positions a Datex encoder data storage, a Datex K-106 control chassis which translates the data to decimal code, and a Data/Log which records magnitude and point identification of each variable on paper tape.—*Datex Corp.*, 1307 *So. Myrtle Avenue, Monrovia, Calif.*

CIRCLE 223 ON READER-SERVICE CARD

HIGH-VOLTAGE CRT

New 5¼"-dia Cathode-Ray Tube, Type K1546, particularly designed for high-frequency oscilloscopes, has writing rates of 1.2 cm/mμsec and can record single millimicrosecond transients. It features linear post-acceler-

PRECISION MEASUREMENT AT ANY FLOW RATE



AMERICAN-WESTCOTT A-88

ORIFICE METERS

Versatile American® Series A-88 mercury-type orifice meters meet the toughest flow measurement requirements – working pressures to 5,000 psi – interchangeable 10, 20, 50, 100 and 200-inch ranges. Recording meters may be equipped with 0-150° F. standard temperature element. Integrating meters integrate static and differential pressure, providing totalized flow indications. Telemetering equipped meters transmit integrated indications to remote locations.

- Manometer body easily cleaned – does not affect calibration.
- Tamper-proof calibration – simple, positive adjustment of float lever arm length.
- Interchangeable ranges – no manifold piping changes.
- Teflon-packed stuffing box is pressure tight, nearly frictionless, never needs lubrication.
- Teflon-packed pulsation dampener externally adjustable under full line pressure.
- Check valves give positive shut-off for over-range protection.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
General Offices: Philadelphia 16, Pa.
Sales offices in principal cities

CIRCLE 102 ON READER-SERVICE CARD

This is the New

TALLY

High-Speed Tape Perforator

It can punch up to 60 characters/sec.

Speed is completely variable. Tally perforators operate asynchronously at any rate to maximum speed. Their unique wire clutch drives let you vary speed for slaving to other equipment, simplifying design of many logical systems.

These features, too

• Self-contained • Accepts tapes of varying widths from 5, 6, 7, or 8 channels • Low maintenance (completely enclosed mechanism is oil-mist lubricated) • Quiet operation • Long life through use of quality components.

It's ready for delivery now

Drop us a line for the full scoop—and the name of your nearest Tally engineering representative. Please address Dept. 5511.

TALLY REGISTER CORPORATION

5300 14th Avenue N.W., Seattle 7, Wash.

CIRCLE 103 ON READER-SERVICE CARD

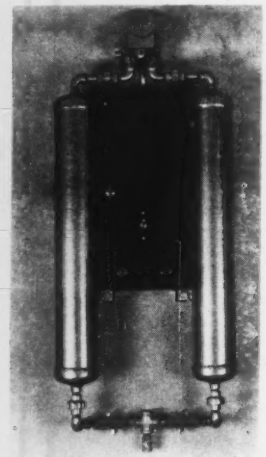
NEW INSTRUMENTS

ation for low pattern distortion and for obtaining high deflection sensitivity. Tube is incorporated as the display device in Du Mont's new # 410 high-frequency oscilloscope.—*Allen B. DuMont Laboratories, Inc., Electronic Tube Sales Dept., Clifton, N. J.*

CIRCLE 224 ON READER-SERVICE CARD

SMALL AIR DRYER

New Air Dryer for quantities from 1 to 25 scfm, with pressures up to 125 psig and temperatures up to 120°F at inlet is fully automatic, using a small amount of heat for reactivation. Com-



ponents are simple: two moving parts, a timer, and a solenoid-type 4-way valve. Throw-away type desiccant towers last several years under normal operation. Dew points at −60°F or below can be reached. Bulletin R-36 contains details.—*Desomatic Products, Inc., 1109 West Broad St., Falls Church, Va.*

CIRCLE 225 ON READER-SERVICE CARD

MATCHED-RESISTOR UNIT

New high-accuracy Resistance Network for a-c analog computer applications packages 6 a-c matched resistors, up to 2.0 megohms each, in less than 2½ cu in, and weighs less

than 2½ oz. Approximate equal value resistors can be matched to better than 0.005% over a temperature range of −15°C to +65°C. The reactive match at 400 cps can be held to 20 μv/v for a 6 resistor network.—*Daven Co., Livingston, N. J.*

CIRCLE 226 ON READER-SERVICE CARD

More Accurate Level Reading of LOW TEMPERATURE LIQUIDS . . .

JERGUSON Large Chamber NON-FROSTING* GAGES

YOU get the highest possible accuracy of reading on low temperature, low boiling point liquids with the patented Jerguson Non-Frosting Gage in the New Large Chamber model . . . because it insures less turbulence at the meniscus, and clear vision at the vision slot.

This new Jerguson model has 6 times larger area at the meniscus than the standard gage, so that there is a marked reduction in turbulence with light gaseous fluids that tend to boil or surge. Moreover, the problem of frosting encountered with these liquids has been eliminated by a patented frost preventing unit extending from the gage glass. This special transparent unit projects beyond the cover bolts and prevents frost from building up over the vision slot.

Here's a dual feature gage that assures greatly increased accuracy of reading for the process industries. If you have a problem with light gaseous fluids, or with gage frosting, it will pay you to investigate the new Jerguson Large Chamber Non-Frosting Gage . . . reflex or transparent.

Jerguson Large Chamber Gage, Transparent Type, with the patented Non-Frosting Gage Glass Extension. Write for literature on this gage, and on other non-frosting Jerguson models.

**Patented*

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

Offices in Major Cities

Jerguson Tress Gage & Valve Co., Ltd., London, Eng.

Pétrole Service, Paris, France

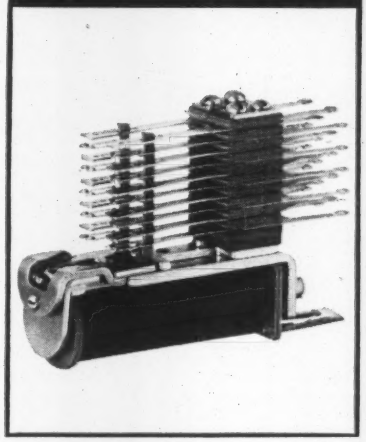
See Booths 1211-13, Chemical Show.

CIRCLE 104 ON READER-SERVICE CARD

Stromberg-Carlson

"TELEPHONE QUALITY"

Relays



. . . featuring new high-voltage types for test equipment or other high-voltage applications.

THE insulation in the new relays withstands 1500 volts A.C.—3 times normal. These high-voltage models are available in Types A, B and E. They are the latest additions to the Stromberg-Carlson line of twin contact relays—all available for immediate delivery.

The following regular types are representative of our complete line:

Type A: *general-purpose relay with up to 20 Form "A" spring combinations. This relay is excellent for switching operations.*

Type B: *a gang-type relay with up to 60 Form "A" spring combinations.*

Type BB: *relay accommodates up to 100 Form "A" springs.*

Type C: *two relays on the same frame. A "must" where space is at a premium.*

Type E: *has the same characteristics as the Type A relay, plus universal mounting arrangement. Interchangeable with many other makes.*

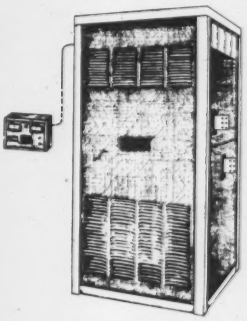
Complete details and specifications are contained in our new relay catalog, available on request. Write Stromberg-Carlson Telecommunication Industrial Sales.

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
113 CARLSON RD. • ROCHESTER 3, N.Y.

CIRCLE 105 ON READER-SERVICE CARD

CONTROLLED RECTIFIERS

New line of Inductro-Capacitron Regulator Controlled Rectifiers (selenium, germanium, and silicon) for instruments, laboratory, industrial, and military applications has automatically regulated output adjustment

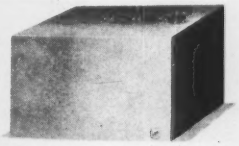


with characteristics similar to saturable reactors, but higher power factor (up to 100%) and efficiency (up to 96%). Voltage or current regulation is within ±0.01% regardless of load variations from 0 to 100%, or line variations of ±10%. Units are available with different ratings up to 500 kw.—*Djeco Div., Djordjevic Engineering Co.*, 1933 *N. Damen, Chicago* 47, *Ill.*

CIRCLE 227 ON READER-SERVICE CARD

DELAY LINE

New Lumped-Constant Delay Line, Model 61-34, with a delay time/rise time ratio of 170/1 has a delay of 200 usec with a rise time of 1.16 usec.

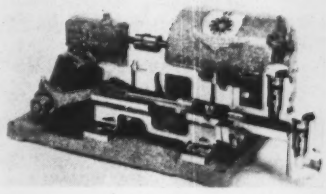


Attenuation is less than 2 db. Frequency response (3 db) = 325 kc. The unit has 50 taps with an accuracy of ±0.2 usec at each tap.—*ESC Corp.*, 534 *Bergen Blvd., Palisades Park, N. J.*

CIRCLE 228 ON READER-SERVICE CARD

PROPORTIONING PUMPS

New high-pressure, low-capacity, variable-volume, reciprocating plunger pumps for feeding from 1.5 gph to 108 gph of corrosive or non-corrosive liquids into chemical processes, etc. feature construction equal heavy duty models and handle pressures to 625



NEW
SPECIFICATION BULLETIN

WEKSLER INSTRUMENTS

How to Specify:

- **Pressure Gauges**
- **Industrial Thermometers**
- **Dial Thermometers**
- **Recording Thermometers**
- **Recording Hygrometers**
- **Bi-Metal Dial Thermometers**

Engineers, architects and contractors are finding this Weksler Specification Bulletin a great time saver!

Designed for "at a glance" information and specifications on Weksler instruments most frequently specified for indicating and recording temperature, pressure and humidity, the bulletin illustrates and describes most of the basic instruments needed in air-conditioning, heating, ventilating, plumbing and piping.

WRITE FOR YOUR COPY OF THE WEKSLER SPECIFICATION BULLETIN

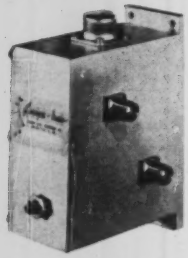
WEKSLER INSTRUMENTS
WEKSLER INSTRUMENTS CORP.
FREEPORT, L. I., NEW YORK
INDICATING AND RECORDING INSTRUMENTS FOR TEMPERATURE, PRESSURE AND HUMIDITY

CIRCLE 106 ON READER-SERVICE CARD

NEW

IRC

ZERO-SETTING
PRESSURE
TRANSMITTER



Measures Differential and Absolute Pressures

●

High Reliability—High Accuracy

●

Excellent for industrial process applications, and military testing

You now have at your disposal an instrument adaptable to a larger number of both industrial and military applications—the new IRC Compu-tran Zero-Setting Pressure Transmitter.

May be zero-set for any environmental situation or to obtain zero output for any pre-set differential between high and low pressure inputs.

The use of two opposing Bourdon tubes with a single magnetic pick-off mounted between makes it possible for the measured fluids to be contained within the tubes and not in the housing. The sealed case provides complete corrosion and explosion protection.

Ranges: 0-100 thru 0-5000 psi static pressure. Differentials up to 100% of range.
High Accuracy: ±0.25%, infinite resolution, output voltage proportional to pressure.
High Reliability: Frictionless magnetic pick-off, guaranteed life 10,000,000 cycles (min.).
High Sensitivity: Sensitive to 1 part in 1000.
Input: 110V or 6.3V AC 60 cycle standard, adaptable to other voltages, frequencies.
Output: 10 to 100 MV to 5 volts. AC or DC. DC output can be fed into instruments calibrated in ranges of 10, 50 or 100 millivolts.
Temperature Compensated: Output stable over full range of ambient temperatures.

Write for full information—Bulletin R-11

Compu-tran

International Resistance Company
COMPUTER COMPONENTS DIVISION
Dept. 452, 401 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd. Toronto, Licensee

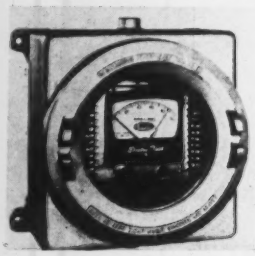
CIRCLE 107 ON READER-SERVICE CARD

psig. Available in Type 304 and 316 s.s., Hastelloy, Carpenter 20, and other steels and with ceramic plungers when corrosive liquids are to be metered.—*Walter H. Eagan Co., Inc., 2336 Fairmount Ave., Phila. 30, Pa.*

CIRCLE 229 ON READER-SERVICE CARD

OVERSPEED/UNDERSPEED CONTROL TACHOMETER

New transitorized Overspeed/Underspeed Tachometer, Electro Tach Model 7120 Series, which provides visible speed indication as well as con-

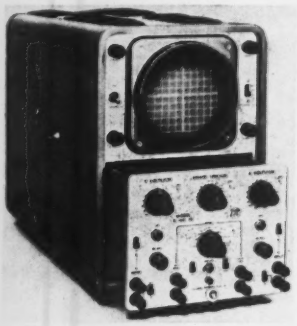


trol, uses a proximity transducer system. It activates associated circuitry when preset value of rpm is reached. —*Electro Products Labs., 4501 Ravenswood Ave., Chicago 40, Ill.*

CIRCLE 230 ON READER-SERVICE CARD

OSCILLOSCOPE PLUG-IN

New Model K-160 Oscilloscope has all signal-generating and processing circuitry (including pre-amplification, switching, time-base generation, cathode ray tube modulation, etc.) con-



tained in a single plug-in system which can be varied as to sensitivity, bandwidth, and other characteristics. Main frame indicator consists of a 5" single-gun CR tube, its associated beam controls, identical X and Y main amplifiers, and a power supply capable of handling any present and future plug-in load requirements.—*Electronic Tube Corp., 1200 E. Mermaid Lane, Phila. 18, Pa.*

CIRCLE 231 ON READER-SERVICE CARD

NOISE MEASURING EQUIPMENT

New Noise Measuring Equipment 123 is a narrow-band r-f spectrum

BARNSTEAD

BANTAM DEMINERALIZER

DOES 5 WATER PURIFICATION JOBS EMPLOYS 5 INTERCHANGEABLE CARTRIDGES

BANTAM

PRESSURE BANTAM

STANDARD CARTRIDGE Produces ion free water at minimum cost . . . removes 1500 grains as NaCl (1300 as $CaCO_3$).

MIXED RESIN CARTRIDGE For operations demanding better than 1,000,000 ohms resistance and neutral pH. Cartridge capacity is 1230 grains as NaCl (1050 at $CaCO_3$). Approximately ⅔ of cartridge capacity is million ohm water or better.

ORGANIC REMOVAL CARTRIDGE Removes organics, organic liquids and gases that would pass through a demineralizer. Effective in removing chlorine. Ideal for pre-treating demineralizer feedwater, for self-purifying high purity rinse systems and other processes where organics or odors in the water are objectionable.

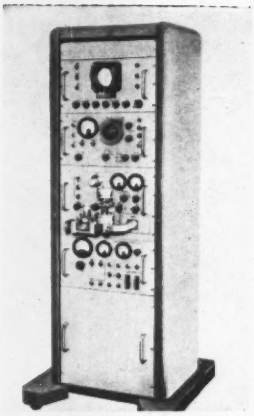
OXYGEN REMOVAL CARTRIDGE Developed for cooling water loops where it is important to maintain low oxygen content to prevent corrosion. Cartridge removes one part per million of dissolved oxygen from 2500 gallons of water, or 6.8 liters (9.7 grains) of oxygen at standard temperature and pressure.

CATION CARTRIDGE Provides (1) precious metals recovery, (2) radio-active isotope recovery, at low cost, (3) also useful for removing volatile amines where heating plant steam condensate is being used as the feedwater for a Still, and (4) where close control over the pH of water is necessary, the cation cartridge in its ammonia or lithium form is effective.

Write for Literature

TRADE MARK REG. U.S. PAT. OFF.
Barnstead
STILL AND STERILIZER CO.
19 LANESVILLE TERRACE BOSTON 31, MASS.

CIRCLE 108 ON READER-SERVICE CARD

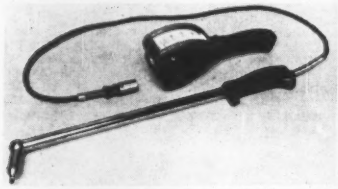


analyzer for determining spectra of spurious a-m and f-m modulations at frequencies close to carrier. Frequency range is from 5.4 to 14.1 kMcps; resolution is 70 cps or 1 kcps bandwidth.—*Ferranti Electric Inc., Electronics Div., 95 Madison Ave., Hempstead, L. I., N. Y.*

CIRCLE 232 ON READER-SERVICE CARD

SURFACE CONTACT PYROMETER

New imported self-contained Surface Contact Pyrometer consists of a hand-held temperature indicator and a surface tracer equipped with a

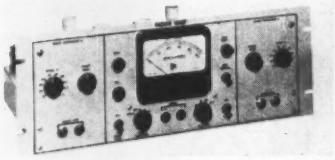


thermocouple head. A large variety of disc, band, ribbon, or needle heads is available for measuring ranges up to 1800°F. Bulletin Ob.8002/e gives details.—*Epic, Inc., 154 Nassau St., New York 38, N. Y.*

CIRCLE 233 ON READER-SERVICE CARD

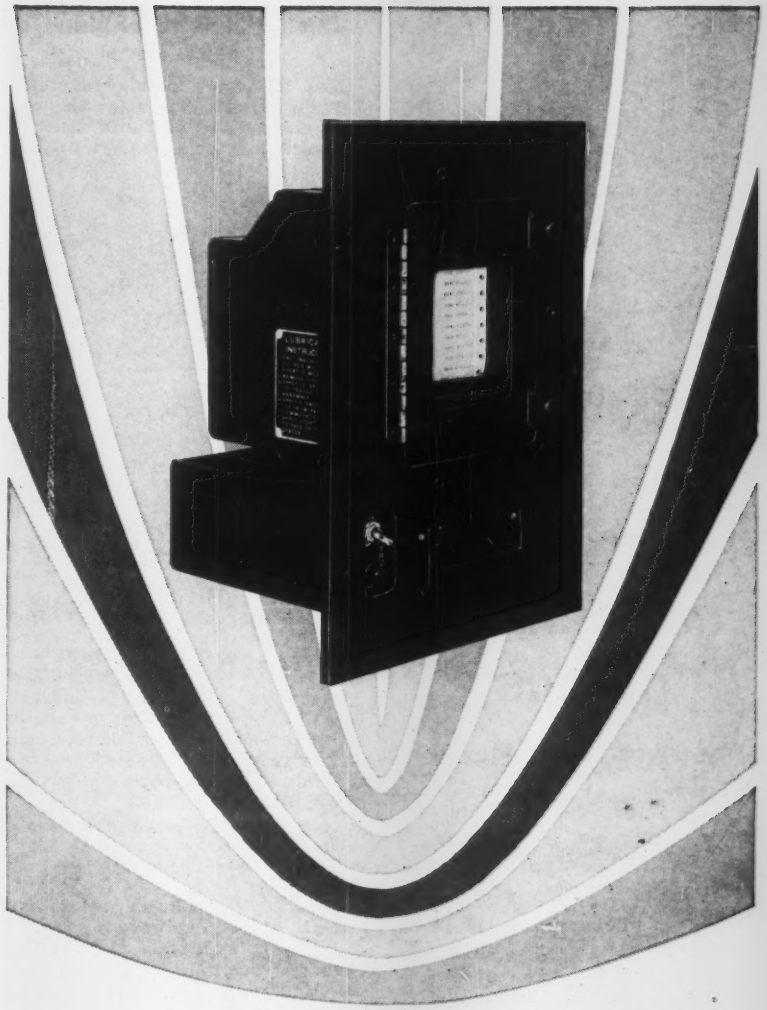
NOISE GENERATOR

New Noise Generator, Model NG1000A, provides an accurate and reliable source of random noise with an amplitude distribution that is



gaussian. Its rms output voltage is variable from zero to a maximum value depending upon the shaping filter used: 6 v rms for the widest bandwidth filter down to 1 v on the narrowest filter.—*GPS Instrument Co., Inc., 180 Needham St., Newton, Mass.*

CIRCLE 234 ON READER-SERVICE CARD



NEW CLARY MILITARIZED PRINTER

WITHSTANDS 50G SHOCK!

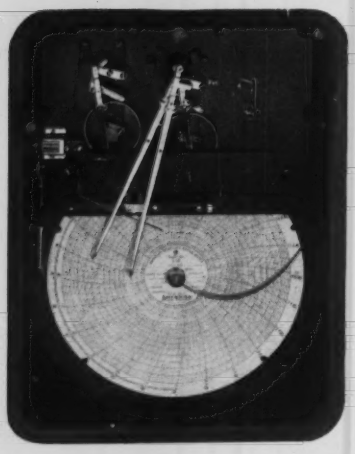
The new Model 2000 series printers designed by Clary will print digital data even under the extreme environmental conditions encountered in military use • These rugged, reliable printers are constructed on a sturdy panel for vertical rack mounting, and contain all necessary electronic equipment for data decoding, digit selection, and control functions of the printer • They are designed to print the output from computers, digital voltmeters, shaft position transducers, electronic counters and digital clocks. In addition, they are ideal in industrial applications where continuous, unfailing operation is required • For complete information on how Clary Model 2000 series can help you, write today for Engineering Bulletin S-120 •

Clary

Electronics Division

San Gabriel, California

CIRCLE 109 ON READER-SERVICE CARD



AMERICAN® INTEGRATING ORIFICE METERS

American Integrating Orifice Meters provide more accurate measurement by the continuous multiplication of the square root of the measured differential by the square root of the absolute line pressure.

Single, double and duplex-integrating models available in a wide range of manometer types and working pressures. Dust-proof, die-cast aluminum cases... Gasclok and electric instrument chart drives. Also supplied with American Telecounter for remote readings.

Ask for Bulletin 401 for complete details.

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1836

General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

CIRCLE 110 ON READER-SERVICE CARD

MODULAR RECORDING SYSTEMS

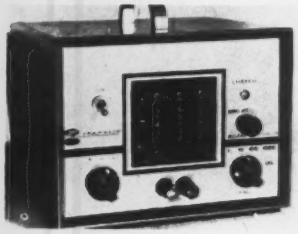
New modular graphic Recording Systems, available in four, six, and eight-channel models with a choice of five interchangeable preamps, produce

clear accurate traces on either standard roll chart or Epsco's unique Z-fold paper. Basic unit consists of a standard 19" relay rack mounted on large freewheeling casters and contains the recorder, master power panel, power supplies and required number of drive amplifiers.—*Epsco, Inc., 275 Massachusetts Ave., Cambridge, Mass.*

CIRCLE 235 ON READER-SERVICE CARD

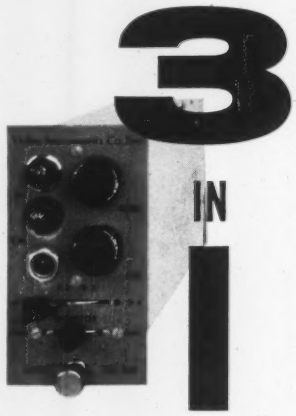
DIGITAL VOLTMETER

New Digital Voltmeter, Model 201, said to be the smallest ever built, is completely electronic in operation, partly transistorized, and free of mechanical step-switches or similar devices. Accuracy is within 1% of full scale on all d-c ranges, and better than 2% above 20% of full scale on



all a-c ranges from 50 cps to 0.6 Mc. Ranges are manually set, with automatic indication 1, 10, 100 and 1000 v ac-dc. D-c polarity indication is also automatic. Other features include mercury-cell calibration, seven tubes and seven transistors, and three cold cathode counting tubes. Internal print-out connections are available. The 11-point unit measures 6-½" high, 8-½" wide, 8-¼" deep, and is available in rack mount.—*Communications & Control Div., Franklin Electronics, Inc., 5901 Noble Ave., Van Nuys, Calif.*

CIRCLE 236 ON READER-SERVICE CARD



power supply
range and balance
calibration *in one*

STRAIN GAGE MODULE

Fully transistorized, the power supply can be set for either voltage or current regulation by means of an internal switch. The span adjustment provides a choice of excitation voltages, continuously variable from 0 to 15 volts. The wide range balance control is suitable for use with virtually all transducers. There is a choice of four precision calibration resistors. Excitation voltage and gage signal voltage monitoring is provided.

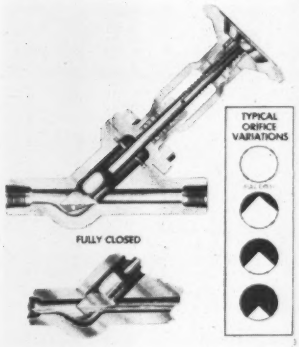
Output	floating, 0 to 15v at 200 ma
Line Regulation	better than 0.1%
Load Regulation	better than 0.1%
Ripple	less than 1 mv
Noise and Hum to Ground	less than 10 microvolts peak to peak when measured with a 350 ohm strain gage bridge
Leakage Resistance	at least 10,000 megohms
Price	$145 plus calibration resistors, fob Santa Monica, Calif.

VIDEO INSTRUMENTS CO., INC.
3002 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 111 ON READER-SERVICE CARD

MANUAL CONTROL VALVE

New Straight Flow Control Valve features direct and unrestricted flow through the valve at all throttling positions which greatly reduces pres-

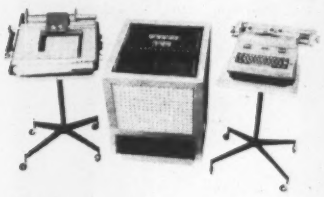


sure drop and friction loss while giving infinitely variable throttling. K factor is only 0.33, 1/30th of most globe valves. Stem has a 90° milled groove in the tip, the apex of which is parallel to the direction of the flow. It does not rotate, but moves up or down in an angle. Sizes available are 1/8" to 4".—*General-American Valve Co., P. O. Box 444, Corona del Mar, Calif.*

CIRCLE 237 ON READER-SERVICE CARD

DIGITAL REDUCTION SYSTEM

New Digital Data Reduction System for reading translucent or opaque records is of modular construction, consisting mainly of (1) an R-2 scanner (the basic transport mech-



anism), (2) a digital reading head (using a decimal encoder to represent amplitudes on an oscillogram), (3) a program control console (receiving the output, a ten-line decimal code), and (4) a typewriter, printer, or plotter, etc.—*Gerber Scientific Instrument Co., 89 Spruce St., Hartford, Conn.*

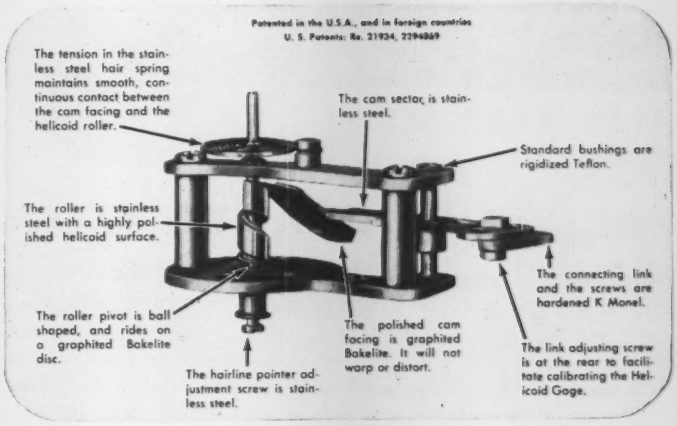
CIRCLE 238 ON READER-SERVICE CARD

PLASTIC GLOVE BOXES

New Plastic Glove Boxes use positive "O" ring seals for guaranteed leak-proof performance, full 18" dia side opening, and have many other design and construction features that were previously only to be found in far more expensive glove boxes.—*Emil Greiner Co., 20-26 North Moore St., New York 13, N. Y.*

CIRCLE 239 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

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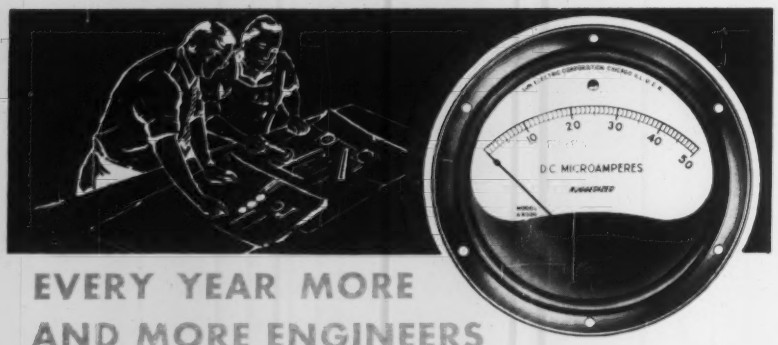
CIRCLE 112 ON READER-SERVICE CARD



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HARLEM AND AVONDALE • CHICAGO 31, ILLINOIS, U.S.A.
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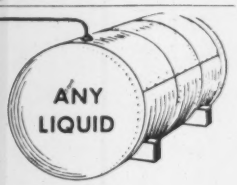
TANK-O-METER
FOR MEASURING TANK CONTENTS
ANY DISTANCE AWAY



TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
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Inclined Manometers for draft, pressure or differential pressure.

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Constant Voltage Unit

REPLACES BATTERIES IN
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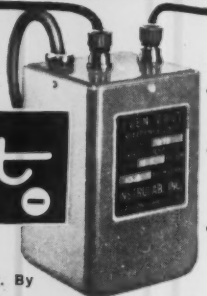
- INDICATORS
- RECORDERS



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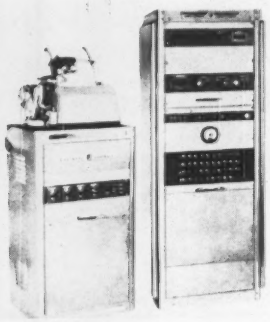
- **Quickly Installed**... Fits present instrument battery space.
- **No Tubes** to replace

CIRCLE 115 ON READER-SERVICE CARD

NEW INSTRUMENTS

WELL TEST CONTROL

New automated Well Test Control System includes new Catalog JS11A Data Receiving Central (left) and previously announced Catalog JS10AD Well Test and Data Accumulation and Transmitting Control

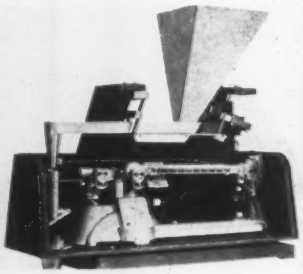


(right). Controller automatically tests up to 40 wells in sequence, then reports by wire to the Data Receiving Central. Latter can accept reports from one to twenty leases at any distance.—*General Controls Co., Industrial Systems Div., 801 Allen Ave., Glendale 1, Calif.*

CIRCLE 240 ON READER-SERVICE CARD

INDUSTRIAL WEIGHING UNIT

New fully-automatic Mini-Weight for handling small quantities of dry materials comprises four basic elements: a supply hopper, an electric

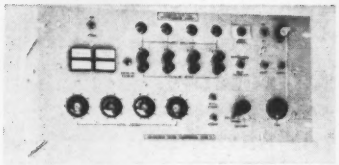


vibratory feeder, a weigh bucket mounted on the weigh beam, and a small air cylinder for operating the bucket gate; and features (1) range: 1 gram to 100 grams; (2) speed: up to 15 weighings/min; (3) accuracy: within ±0.1 gram of most materials; (4) controls which are mounted in a remote control box.—*Glengarry Processes Inc., Bay Shore, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

PULSE GENERATOR

New series of Programmed Pulse Generators (exemplified by illustrated Model II-507B), delivering four different pulse programs to two signal outputs with sync pulses at various

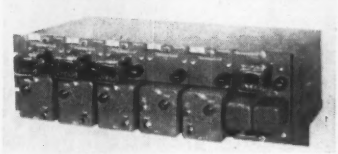


PRF's, features modular-construction transistors and cold cathode gas tubes which reduces power consumption to 8 watts.—*Iconix, Inc.*, 945 *Industrial Ave., Palo Alto, Calif.*

CIRCLE 242 ON READER-SERVICE CARD

TONE SIGNALLING SYSTEM

New modular Tone Signalling System, using a single type plug-in transistor throughout, employs audio frequency tones of pre-determined frequency as a mode of signalling for

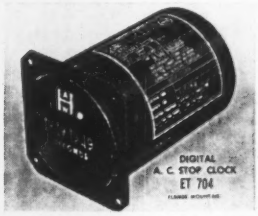


both telemetry and control functions. The tones may be transmitted over ordinary, leased telephone pairs, private lines, or radio links. Up to 26 different tones, with ensuing functions may be transmitted simultaneously in both directions over a single telephone pair of normal voice quality. —*Hammarlund Mfg. Co.*, 460 *West 34th St., New York* 1, *N. Y.*

CIRCLE 243 ON READER-SERVICE CARD

A-C AND D-C STOP CLOCKS

New line of Digital A-C and D-C Stop Clocks features electrical reset which permits local or remote control, or automatic operation where succes-



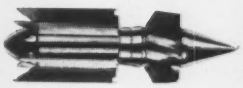
sive time intervals must be measured. A-C Stop Clocks, Series L15100 and L15200, (see illustration) are for 60- and 400-cps operation; Digital D-C Stop Clocks, L15300 Series, are for 20 to 30 v. Clocks meet requirements of specification MIL-E-5272A.—*A. W. Haydon Co.*, 228 *N. Elm St., Waterbury* 20, *Conn.*

CIRCLE 244 ON READER-SERVICE CARD

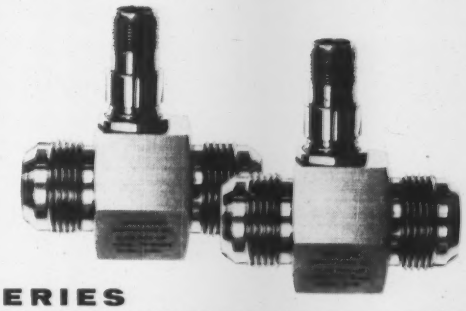
LOW-TORQUE PULSE COUNTER

New low-torque Pulse Counter Model 2010, activated by a stepping motor, is "standard" with six drums,

Waugh FLOW SENSORS . . .



a significant advance in flow instrumentation



FF SERIES FLUID BEARING

FB SERIES BALL BEARING

The new Waugh FF and FB Series flow sensors are an outgrowth of more than 25 years experience in the design and production of flow instrumentation. Completely new, yet proven through strenuous testing in actual use, these flow sensors have almost universal application and are the basis for our standard flow instrumentation line.

Both models feature extremely high accuracy, linearity and *infinite* life in use. Decreased bearing drag aids to linearity and practically eliminates maintenance problems.

The turbine rotor of the FF sensor floats entirely on a filtered film of the liquid being measured, obviating wear from either radial or thrust friction. The FB turbine is supported by two ball bearings, which are lubricated and scavenged by the fluid in the line.

FLUIDS — Meters hydraulic oils, cryogenics, corrosive fluids, jet-aircraft fuels, and many other difficult to handle fluids.

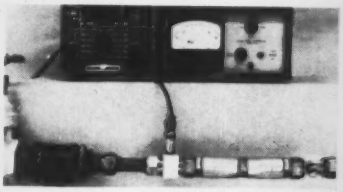
LINEARITY — ± ¼%.

REPEATABILITY — The absence of conventional bearing surfaces results in reproducability within 0.1% of flow rate.

EXPECTED LIFE — Infinite.

SIZES and FLOW RANGES — Standard ranges are from 2 to 500 GPM, in sizes from ⅝" to 2¼" line o.d. The FB series is available also in ½" line o.d. model with flow range from 1 GPM. Standard models available in bulkhead length. Other sizes and ranges are available.

LINE PRESSURE — Standard stainless steel unit is suitable for 5000 psi, with higher pressure ratings available.



This FF Series sensor has been operating **continuously** at 35 GPM for 4357 hours to date, and is still functioning perfectly. Expectancy unlimited!

Write for technical bulletin

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CONTINUOUS ANALYSIS OF CHEMICAL PROCESS SYSTEMS

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FLUID POWER CONTROL

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5.
PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY

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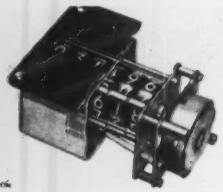
NEW INSTRUMENTS

but is also available in 2-, 3-, 4- and 5-drum types. Planet Gear drive with planetary gears which are always in

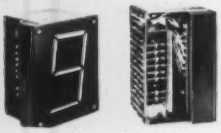


mesh, eliminates many disadvantages of mechanical counters and Geneva-type movements. Numbers are ⅛" and speed is 40 count/sec.—*Haydon Instrument Co., 165 W. Liberty St., Waterbury 20, Conn.*

CIRCLE 245 ON READER-SERVICE CARD

AC-DC 3" DIGITAL READOUT

New 3" Digital Readout, Model SGS-103, using a switching circuit consisting solely of the resistor and capacitor matrix and neon bulbs, is

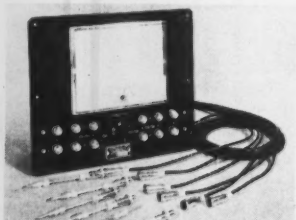


adaptable to applications such as digital voltmeters, aircraft instruments, clocks, displays, or as visual channel reporter for TV sets, etc.—*Electronic Equipment Div., I.D.E.A., Inc., 7900 Pendleton Pike, Indianapolis 26, Ind.*

CIRCLE 246 ON READER-SERVICE CARD

TEMPERATURE INDICATORS

New Thermi-Tran Temperature Indicators are activated by thermistors which permit the use of ordinary copper wire leads of any practical length with negligible effect on ac-



curacy of meter readings. Accuracy is ±2% of full scale. There are two series available: Series KC-532 a single-channel, portable unit single- or dual-temperature-range scales. Series KC-871 (as illustrated) is a panel-mounted, multi-input unit with provision for up to six temperature sensing channels and single or dual temperature ranges.—*Kahn and Co., P. O. Box 516, Hartford 1, Conn.*

CIRCLE 247 ON READER-SERVICE CARD

HARDNESS TESTING

SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

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FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484)

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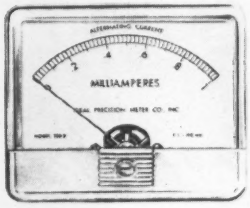
CIRCLE 119 ON READER-SERVICE CARD

PANEL MOUNTED ELECTRICAL INDICATOR

New Model 600 PI, 6" D-C General Purpose Panel Meter features a case of styrene plastic with great clarity and easy readability. D'Arsonval

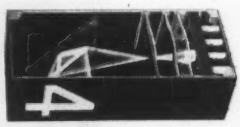


movement guarantees minimum accuracy of 2% (full scale deflection). Mirrored scales and spade, lance and knife-edge pointers are available.—*Ideal Precision Meter Co., Inc., 126 Greenpoint Ave., Brooklyn 22, N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

DIGITAL READOUT

New 90° projection-type Readout, which receives the desired digit from the top of the unit and displays it on the front viewing screen via a

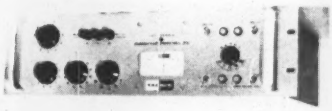


mirror, features a condensing lens which contains twelve individual "positions" that have printed on them the desired digit and is activated by an individual light. Digit is 3-¾" high by 2" wide.—*Industrial Electronic Engineers Inc., 3973 Lankershim Blvd., North Hollywood, Calif.*

CIRCLE 249 ON READER-SERVICE CARD

HIGH-ACCURACY VOLTMETER

New Model 301 DC Standard and Null Meter, with a range from one to 501 v full scale and an absolute accuracy of 0.02%, operates on a null principle, balancing the input against a self-contained power supply. By setting the instrument's calibrated

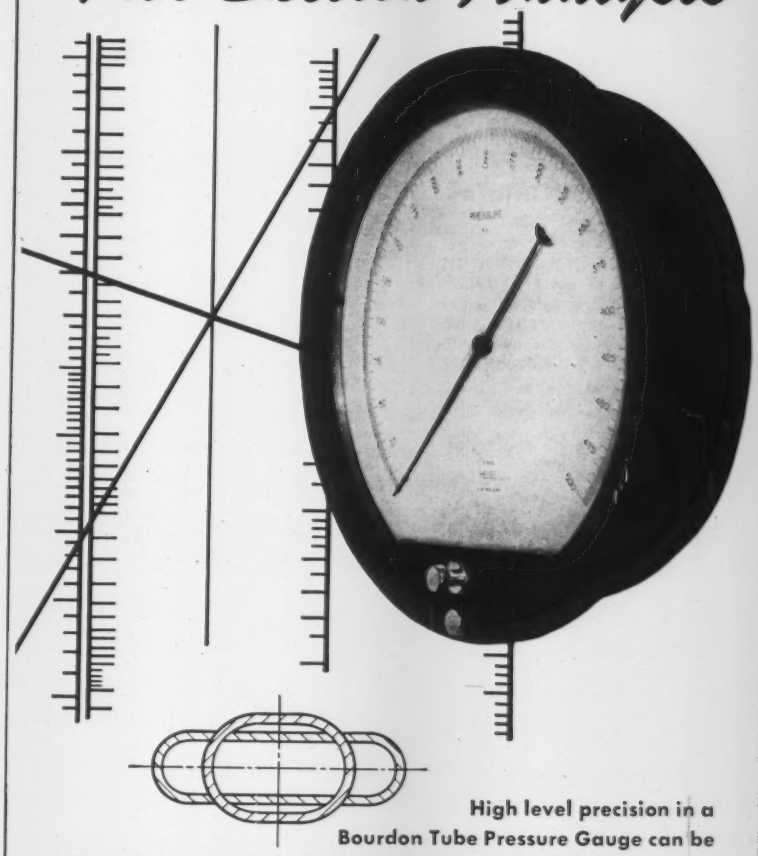


dials to null the unknown d-c voltage, the value of the input, can be read directly. When used as a secondary d-c power supply, the instrument supplies one to 501 v at up to 20 ma. Unit is available as portable bench model and in a 19" rack mount. Bulletin 15-7 contains details.—*Kin Tel Div., Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 12, Calif.*

CIRCLE 250 ON READER-SERVICE CARD

HEISE GAUGES

Tube Section Analysis



High level precision in a Bourdon Tube Pressure Gauge can be achieved only by scientific design of tube section and scrupulous selection of material.

The Bourdon Tube is a hollow, curved beam acted upon internally by fluid pressure in widely varying degree and affected, in some applications, by broad temperature ranges. Uniform distribution of displacement throughout the gauge range and precise control of induced stress requires individual analysis of each gauge application.

Using data and formulas developed by their own laboratory, Heise engineers specify a length-width ratio, wall thickness and all information for maximum performance in each application of their gauges.

Pressure Ranges 15 to 50,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $166.75 **DELIVERY WITHIN 30 DAYS**

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

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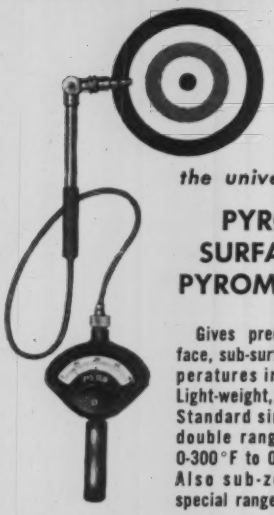
UNEXCELLED ACCURACY



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PYRO SURFACE PYROMETER

Gives precise surface, sub-surface temperatures instantly. Light-weight, rugged. Standard single and double ranges from 0-300°F to 0-1500°F. Also sub-zero and special ranges.

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MICO *Precision Apparatus*

NEW HEAVY DUTY 2 & 3 DIMENSIONAL ENGRAVER

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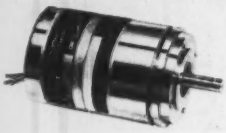
CIRCLE 122 ON READER-SERVICE CARD

NEW INSTRUMENTS

TACHOMETER GENERATOR

New Size-20, Model U720-001, Uncompensated Tachometer Generator features output-voltage linearity of 0.03%, very slight frequency change

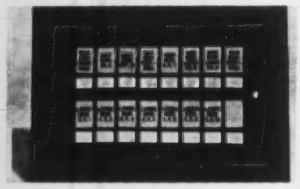


between input and output voltages and an output voltage variation of ±0.1% over the specified temperature range.—*Kearfott Co., Inc., Little Falls, N. J.*

CIRCLE 251 ON READER-SERVICE CARD

ANNUNCIATORS

New type Lamp Annunciator (Series DOM) features rectangular lamp units and momentary-contact push buttons. Annunciators are supplied with two sizes of rectangular



lamps and push buttons, #1025PB (¾" x ½"), or 1126PB (1-⅜" x ¾"), and are available with or without individual reset buttons, cabinets and relays, etc.—*H. R. Kirkland Co., 800 King St., Morristown, N. J.*

CIRCLE 252 ON READER-SERVICE CARD

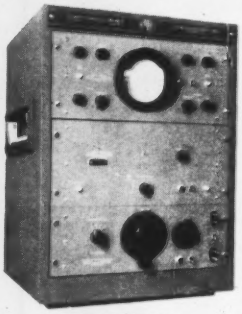
ENCLOSED SWITCHING UNITS

New standardized line of Linear Control Units comprises two two-circuit double-break snap-action switches which are operated by adjustable

cams mounted on a rigid, heavy-walled sliding actuator tube, coupled to an air cylinder or sliding machine member. Five standardized sizes are available for specific stroke length requirements: 0-4" stroke; 0-8"; 0-12"; 0-18" and 0-24".—*Linear Controls Co., 3400 Main, Skokie, Ill.*

CIRCLE 253 ON READER-SERVICE CARD

ALI TYPE 7000-B AUDIO PRIMARY PHASE STANDARD



FEATURES:

- ±0.05° Phase Shift Accuracy
- 30 cps to 20 kc Frequency Coverage
- 0° to 360° Continuous Phase Shift
- Ultimate Accuracy of ±0.01°
- Self-Calibrating
- Long-Term Operating Reliability
- Lissajous Pattern Presentation

The Type 7000-B Audio Primary Phase Standard supplies two sinusoidal voltage signals whose phase relationship is known to ±0.50° and is continuously variable from 0° to 360°. The frequency of the two signals is the same and is set at one selected frequency from 30 cps to 20 kc.

Specifications

Frequencies: Any single frequency from 30 cps to 20 kc. Frequency is set with an accuracy of ±0.05%.

Accuracy of Phase Angle: ±0.05°. For angles which are multiples of 1°, carefully taken readings are accurate to 0.01°.

Output Voltage Range: 1 to 12 volts (rms).

Output Distortion: Total harmonic distortion less than 0.05%, provided output voltage is within specified range of 1 to 10 volts (rms).

Output Impedance: Approximately 200 ohms (from cathode follower).

Power Supply: 105-125 volts, 50-60 cycle electronic-regulated, self-contained supply, requiring approximately 450 watts.

Physical Specifications

Dimensions: 21¼" wide x 31" high x 21½" deep.

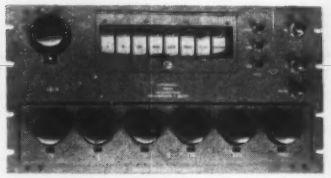
For full details and specifications, wire or call

ACTON LABORATORIES, INC.
531 Main Street, Acton 9, Mass.
COlonial 3-7756

CIRCLE 123 ON READER-SERVICE CARD

GUARDED WHEATSTONE BRIDGE

New, vastly improved 4232-B High-Precision Guarded Wheatstone Bridge features enclosed rheostat dials and high-quality selector switches for fast



and easy operation. Guarding assures accuracies of ±0.01% up to 1 megohm and ±0.02% up to 100 megohms. The bridge has wide measurement range (from 0 to 11,111 megohms) or 100 times greater than the old Anthony-Pattern bridge.—*Leeds & Northrup, 4934 Stenton Ave., Phila. 44, Pa.*

CIRCLE 254 ON READER-SERVICE CARD

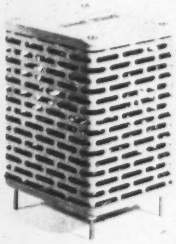
SYNTHETIC INSTRUMENT OIL

New Synthetic Instrument Oil, Anderol L-281, is a medium-viscosity diester oil for use in precision instruments. Physical characteristics of the synthetic lubricant include low evaporation rate (it remains fluid up to 100 times longer than ordinary instrument oils), a temperature range from −75°F to +350°F, high penetration, and remarkable oxidation stability.— *Lehigh Chemical Co., Industrial Lubricants Div., Chestertown, Md.*

CIRCLE 255 ON READER-SERVICE CARD

POWER SUPPLIES

New PI (plug-in) series of Power Supplies for use with computing systems or strain gage apparatus, having a capacity of 15-w output (fixed or variable) with 0.1% regulation, is made in voltage ranges from 0 to 300



vdc such as, 100 vdc at 50 ma., or 50 vdc at 100 ma. A transistor regulator circuit provides fast response and accurate regulation for both line and load changes. Recovery is less than 50 usec; ripple is 0.01%; and overshoot is less than 1.0% of the voltage setting.—*Mid-eastern Electronics, Inc., 32 Commerce St., Springfield, N. J.*

CIRCLE 256 ON READER-SERVICE CARD

NEW !

The 603-607 and the 621 series of direct recording oscillographs, the newest in Midwestern's **EXPANDED** line of precision electronic test data instruments, are the results of years of proven leadership in the field of oscillography. Write for complete brochures and performance information.

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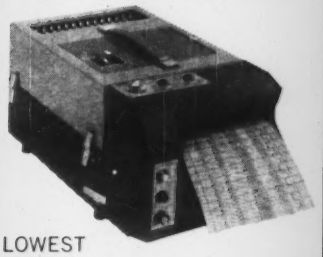

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Buy ONE Manometer
Use it for ALL FLUIDS!

- Dynametrics U-Tube and Single Tube precision-built Manometers feature universal compatability with every manometer fluid. No need to change wetted parts when fluids are changed.
- Wetted parts of Pyrex, stainless steel, and non-deteriorating seals will not corrode in presence of water, mercury, TBE, hydrocarbons.
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Large multitube and photopanel units also available for maximum utility in minimum space.

Write for Dynametrics "Pressure Measuring Instruments" Catalog

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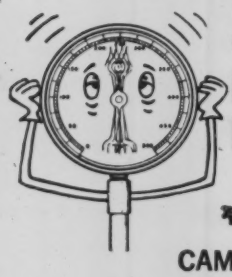

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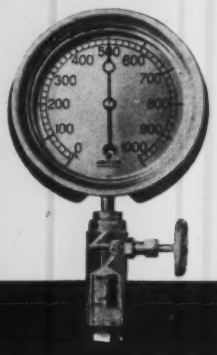
A Campbell Micro-Bean cures a headache ten times as fast as aspirin provided the headache is caused by a pressure gauge with a bad case of the jitters. Rapidly becoming the standard pulsation dampener in many industries all over the world.



Write for Literature–

J. A. CAMPBELL COMPANY
645 East Wardlow Road
Long Beach 7, California

CIRCLE 126 ON READER-SERVICE CARD

new plants and mergers

LEEDS & NORTHRUP on September 18, 1959 dedicated its new $2 million research center in North Wales, Penna.,

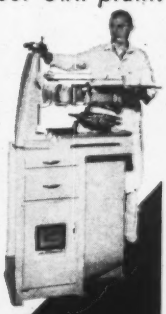
covering 65,000 sq ft, with the provision of tripling the size of the building, which now houses 129 scientists and supporting personnel under the direction of *Dr. Raymond C. Machler.*

PERKIN-ELMER's Electro-Optical Div. has opened advanced research and development facilities in Los Angeles.

HOUSTON INSTRUMENT CORP. announces a merger with Crump Instrument Corp., Houston Magnetic Products, Inc., and Instrument Mirror Mfg. Co., which will be operated as divisions of Houston Instrument.

GREEN *Pantograph Engravers*

ELIMINATE DELAYS!
Keep the work in your own plant.



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The Model 106 has proven incomparable for speed and accuracy . . . yet reasonably priced.

Cutter grinders, rotary tables, master letters, compound slides, name plates and all required accessories. For complete information, write to

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 575 pounds — rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Micrometer adjustment for depth of cut
- Ball-bearing construction throughout — super-precision ball bearing spindle
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- Ratios 2 to 1 to infinity — master copy area 26" x 10"
- Vertical range over 10"

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383 PUTNAM AVENUE, CAMBRIDGE 39, MASS.

CIRCLE 127 ON READER-SERVICE CARD

VARIAN ASSOCIATES has made plans to increase its Stanford Industrial Park facilities to 1,000,000 sq ft within the next few years.

people in the news

SAMA reports that *Thomas C. Clark*, assistant to the sales vice president of Veeder-Root, Inc., was sworn in to serve as the scientific industry's representative in the Commerce Department through July, 1960.

Du MONT announces promotion of *Joseph Burns* to manager of the cathode-ray tube engineering laboratory.

GENERAL CONTROLS CO. announces that *Dr. Leonard Pode* has joined the Electronic Systems Division as chief engineer.

OPTICS

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COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
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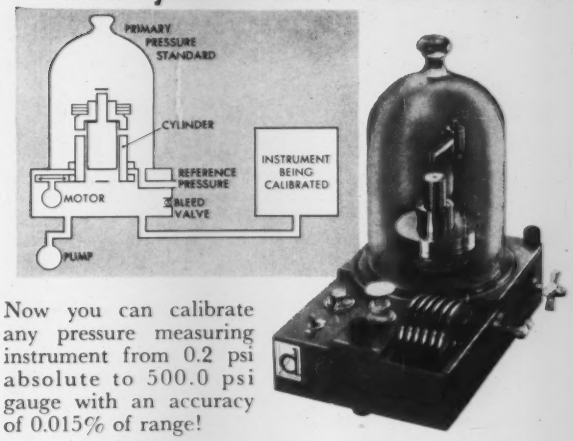
CIRCLE 128 ON READER-SERVICE CARD

NEW! PRIMARY PRESSURE STANDARD with Cyclic Bi-directional Rotation



Now you can calibrate any pressure measuring instrument from 0.2 psi absolute to 500.0 psi gauge with an accuracy of 0.015% of range!

- Exclusive cyclic bi-directional rotation of cylinder minimizes lift error
- Four pressure ranges
- Use any reference pressure from zero to one atmosphere absolute
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Write for Technical Bulletin on Primary Pressure Standard.

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Specify!
THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
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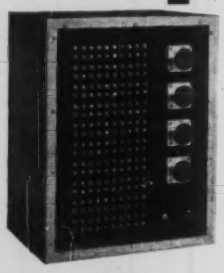
PACE



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PACE BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION —

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- **REFERENCE TEMPERATURES** from 25° F above ambient to 250° F — *special models for reference temperatures below ambient.*
- **CHANNEL CAPACITY** 6 to 100 channels in standard 110 volt rack or cabinet models.
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CIRCLE 131 ON READER-SERVICE CARD

PEOPLE—CONTINUED

E. R. Gamson
Telemeter

J. H. Covode
Hagan

T. J. Barthlow
Hagan

TELEMETER MAGNETICS announces election of *Edwin R. Gamson*, general manager of the Components Division, to vice president of the company.

HAGAN CHEMICALS & CONTROLS has appointed *John H. Covode* manager of sales—special products and *Thomas J. Barthlow* manager of sales—process systems, both for the controls division.

NACIMCO PRODUCTS has appointed *Don Slote* sales manager.

SERVONIC INSTRUMENTS announces appointment of *Roy Steckmesser* as general sales manager.

FOXBORO COMPANY's new systems engineering group will be under the direction of *Robert Silva*.

LIBRASCOPE has appointed *Wayne Blackburn* director of the newly established Applied Research Department, and *Charles Krill* director of engineering of the Burbank Division.

NEW MARTIN-DECKER PRECISION TEST GAUGES

Designed for the Ultimate in Accurate Pressure Measurement

Write for descriptive brochure M-28A

Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 100 square inches of panel space.
- Ni-Span C Bourdon tube corrects temperature effect.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

Select territories available to test equipment or gauge distributors. Write direct to C. L. Howard, Industrial Sales Manager.

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LONG BEACH, CALIFORNIA

CIRCLE 132 ON READER-SERVICE CARD

New...from MARSH!

Conduit-type Master-mite. Grommet-type also available.

Small solenoid valves that fill a BIG order

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
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Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A.C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Write for new bulletin

MARSH INSTRUMENT COMPANY
Dept. 42, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

CIRCLE 133 ON READER-SERVICE CARD

D. Slote
NACIMCO

R. Steckmesser
Servonic

H. I. Chambers
Consolidated

R. V. Long
Vapor Recovery

A. E. Aune
Burndy

B. N. Fisher
Telecomputing

CONSOLIDATED ELECTRODYNAMICS announces appointment of *Herbert I. Chambers* as associate director of the DataTape Division.

VAPOR RECOVERY SYSTEMS CO. announces that *Ray V. Long* has been named executive vice president, *Arnold A. Wilcox* vice-president-manufacturing, and *H. Dickinson* vice-president-engineering.

BURNDY CORP. has named *Alan E. Aune* as sales manager of the Omaton Division.

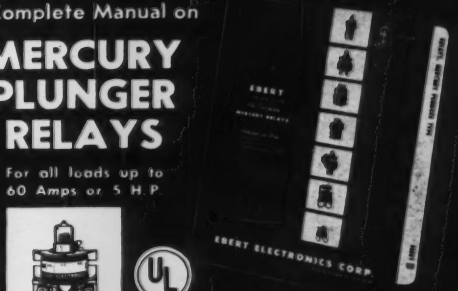
TELECOMPUTING CORP. has advanced *Berne N. Fisher*, general manager of the Brubaker Electronics Div., to vice president of the corporation.

FREE ENGINEER'S FACT FILE

A Complete Manual on

MERCURY PLUNGER RELAYS

For all loads up to 60 Amps or 5 H.P.



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FREE: Brand new edition, fully illustrated. Rated as the standard reference manual on all types and applications of Mercury Plunger Relays. 1, 2 and 3 pole hermetically sealed, compact and miniature units that provide millions of continuous makes and breaks without maintenance. No pitting or corrosion.

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CIRCLE 134 ON READER-SERVICE CARD

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by C. S. Beard. New "one-book" reference on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. Paper bound, 236 pages, 1957 **$2.00**

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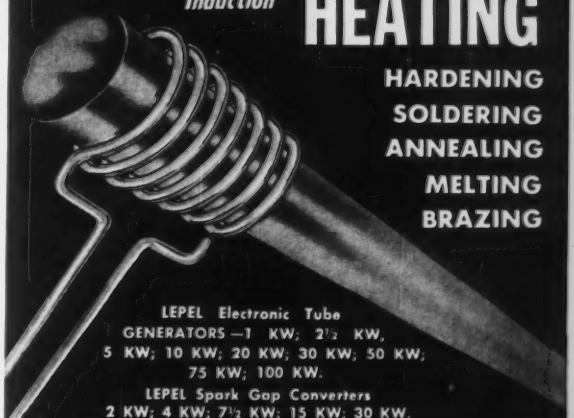

LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

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CIRCLE 135 ON READER-SERVICE CARD

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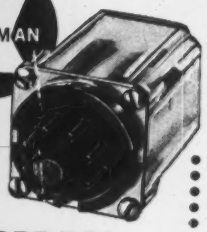

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	✓	T/C Cells—On Stream	✓	
✓	✓	Temperature Regulated Cells • Hot Wire —to 400° C • Thermistor—to 100° C	✓	✓
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CIRCLE 137 ON READER-SERVICE CARD

new literature

CONTROL SYSTEMS

ELECTRONIC CONTROL. 8-page Bulletin A-913 is "A Functional Guide to AutroniC Control Equipment," arranged by process variables.—Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

CIRCLE 257 ON READER-SERVICE CARD

CONTROL COMPUTER. 6-page folder Form 3J3733 contains all details on the new RCA 110 solid-state industrial control computer system.—Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.

CIRCLE 258 ON READER-SERVICE CARD

GAS ANALYSIS CONTROL. 4-page Performance Report G10.3-1 gives an illustrated description how a Bailey Oxygen Analyzer was used to control glass tank excess air at Diamond Glass Co., Royersford, Penna.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

CIRCLE 259 ON READER-SERVICE CARD

CONTROL SYSTEM. 2-page Bulletin 5904 explains the Femco TMC telemetering, monitoring and remote-control system for gas distribution systems.—Femco, Inc., Irwin, Penna.

CIRCLE 260 ON READER-SERVICE CARD

TEMP CONTROL SYSTEMS. 8-page folder describes "Precision Temperature Controls in Industrial Plants."—Fenwal Inc., Pleasant St., Ashland, Mass.

CIRCLE 261 ON READER-SERVICE CARD

POWER CONTROL UNITS. 8-page Bulletin S-1075 describes new line of power control units utilizing magnetic gating amplifiers driving silicon-controlled rectifiers.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

CIRCLE 262 ON READER-SERVICE CARD

VALVES, ACTUATORS

DRIVE AND TIMING UNIT. 4-page Bulletin 1107 describes and explains uses of Gas Drive, a completely self-contained air- or gas-powered instrument drive and timing unit which operates indefinitely and without attention.—Rockwell Mfg. Co., Meter and Valve Div., 400 North Lexington Ave., Pittsburgh 8, Pa.

CIRCLE 263 ON READER-SERVICE CARD

REGULATORS. 4-page Bulletin J-DI gives data on ductile-iron regulators and control valves with sliding-gate and plate.—OPW Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 264 ON READER-SERVICE CARD

BUTTERFLY VALVES. 4-page Condensed Bulletin 50-1 illustrates, and tabulates specs for butterfly valves.—Continental Equipment Co., Coraopolis, Penna.

CIRCLE 265 ON READER-SERVICE CARD

PRESSURE REGULATORS. 4-page folder describes Type B pressure reducing valves.—Atlas Valve Co., 280 South St., Newark 5, N. J.

CIRCLE 266 ON READER-SERVICE CARD

PRESSURE, WEIGHT

PRESSURE TRANSDUCER. 2-page Bulletin E-106 gives description and specs of Hi-Ac-Tran Model 106 transducer for adapting new or old pneumatic equipment to electronic control. —Associated Control Equipment, Inc., 853 Fourth Ave., Coraopolis, Penna.

CIRCLE 267 ON READER-SERVICE CARD

DRY MATERIALS FEEDER. 4-page Bulletin 35.20-2 describes with illustrations the Model 37-20 belt gravimetric feeder for continuous weighing and feeding dry materials at high rates.—Omega Machine Co , Div. of B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

CIRCLE 268 ON READER-SERVICE CARD

ELECTRONIC WEIGHING. 8-page Bulletin 959-G340 contains chart and description of components, instruments, and accessories for electronic scale instrumentation.—Streeter-Amet Co., Grayslake, Ill.

CIRCLE 269 ON READER-SERVICE CARD

BULK WEIGHING SCALE. 2-page Product Data Sheet 5902 gives dimensional sketch, specs, and description of automatic bulk weighing scale HHH-38.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

CIRCLE 270 ON READER-SERVICE CARD

BULK MATERIAL WEIGHT. 24-page Catalog 14 explains application of a standardized system of instrumentation to batch and continuous weighing methods.—Weighing & Control Components, Inc., 646 E. County Line Rd., Hatboro, Penna

CIRCLE 271 ON READER-SERVICE CARD

TEMPERATURE

THERMOWELLS. 6-page bulletin illustrates and describes bimetallic thermometer wells.—Trinity Equipment Corp., Cortland, N. Y.

CIRCLE 272 ON READER-SERVICE CARD

THERMOSTATS. 2-page Bulletin T-5 illustrates and describes line of mercury-in-glass fixed-contact thermostats, adjustable thermoregulators, and magnetic relays.—Precision Thermometer & Instrument Co., 1434 Brandywine St., Phila. 30, Pa.

CIRCLE 273 ON READER-SERVICE CARD

THERMISTOR THERMOMETERS. Two 2-page catalog sheets contain specs and illustrations of the Models 43 and 44 Thermistemp Telethermometers.—Yellow Spring Instrument Co., Inc. Yellow Spring, Ohio.

CIRCLE 274 ON READER-SERVICE CARD

TEMPERATURE STANDARDS. 8-page Technical Memorandum on "Temperature Standards at O°C" makes a comparison between the temperature established by an ice bath and the triple point of water cell standard.—Trans-Sonics, Inc., Burlington, Mass.

CIRCLE 275 ON READER-SERVICE CARD

CONSTANT TEMPERATURE BATH. 4-page Bulletin WB describes features and operation of Thermonitor-controlled constant-temperature bath.—E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill.

CIRCLE 276 ON READER-SERVICE CARD

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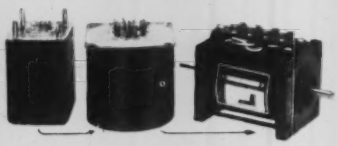

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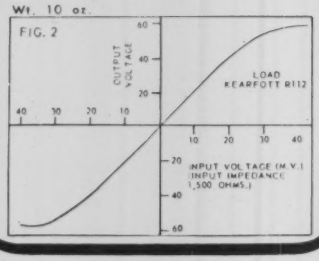

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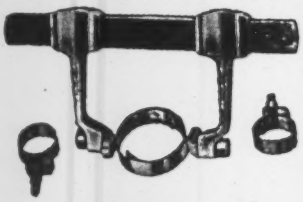

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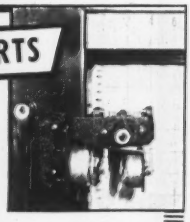

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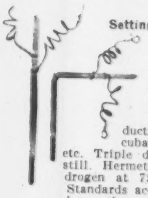

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ANALOG COMPUTER. 2-page brochure describes and illustrates analog computer CM-2 —Southwestern Industrial Electronics Co., a div. of Dresser Industries, 10201 Westheimer Rd., P. O. Box 22187, Houston 27, Texas.

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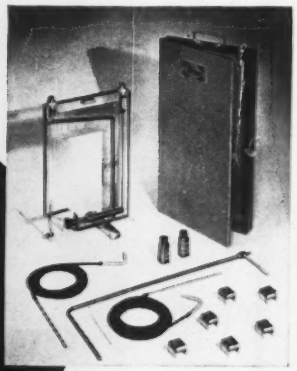

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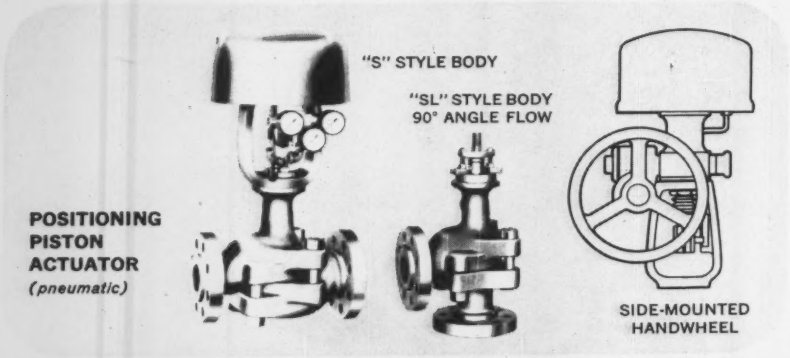

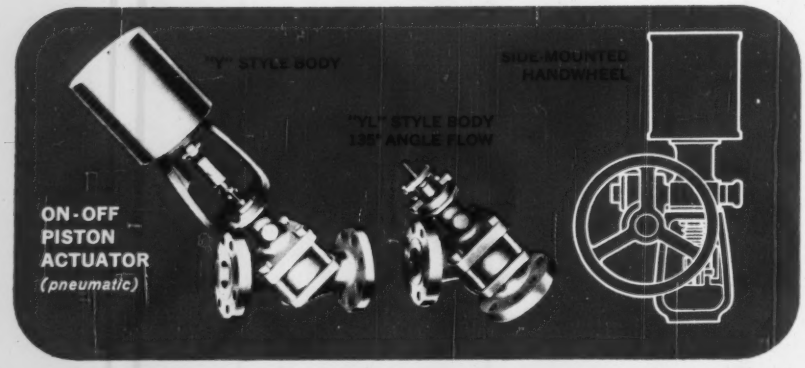

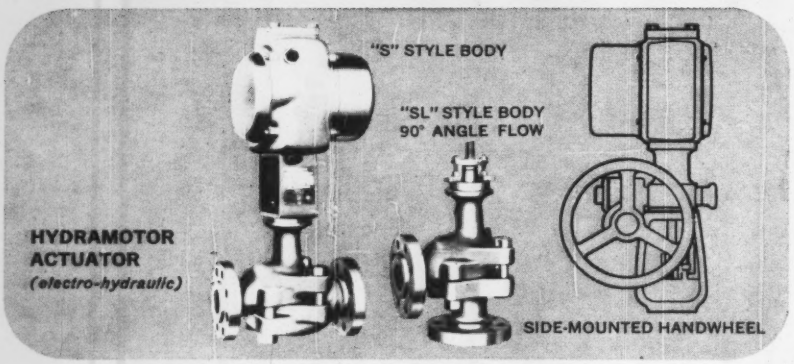

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